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THE REPUTED CONFLICT BETWEEN THE LABORATORIES AND CLINICAL MEDICINE[1]

By the late Dr. C. F. HOOVER

WITHIN the past few years the idea has frequently been expressed that there is a conflict between the "laboratories" and the practice of medicine. Just how this impression has gained currency is difficult to express in a few words because any particular conflict may start from so many different causes and may come from either side. We should not wonder at this conflict, because it is only in the past thirty-five years that the laboratory has shared much in clinical diagnosis. Formerly chemistry and microscopy contributed only to post-mortem studies, and instruments of precision that can be used in clinical studies are very new. Like the art of medicine, the merits of laboratory devices depend on a directing intelligence, and no kind of contention is inspired by such a warm spring of egotism as the defense of one's intellectual self-esteem. Until very modern times, laboratory work was the avocation of practitioners, but now the laboratory methods have grown so much in importance and in variety that their employment has attained the dignity of a vocation. Naturally want of knowledge, prejudice and professional vanity may lead one side to belittle the other's importance. Nothing so readily stirs the vanity of a member of any of the learned professions as an attempt to dim the light of which he is conscious. So we have not far to seek for the reason why we should occasionally meet with champions of contending views who resent either the tyranny or obstinacy of their opponents.

Every honest practitioner of medicine welcomes all

[1] This paper was read by Dr. Hoover before the Cleveland Academy of Medicine. It is presented for publication by his wife, Katherine Fraser Hoover.

aids to diagnosis and will employ all devices that furnish knowledge or supplement his diagnostic needs. Nor should he resent the substitution of an instrument of precision for his art if the instrument is more dependable. Such a mental attitude savors of the trade union and is unworthy of a learned profession.

A serious and estimable complaint has come from practitioners who do not decline laboratory contributions but do object to the complaisant submissiveness with which practitioners yield to tests and instruments of precision and thus seek to escape their professional obligations. This tendency is perceptible not only in private practice but also in teaching hospitals where the art of medicine may be poorly cultivated and voluminous laboratory reports are exhibited as evidence of profound clinical study.

Proficiency in the art of diagnosis is gained only at the expense of patient toil and much time. An unskilled craftsman gladly takes shelter under the pretensions of precise devices that hide his poverty of resources. By this statement it is not intended to scoff at instruments of precision or to discourage the mastery of their employment. What is disapproved is submission to these devices without control by clinical logic. Instrumental devices always give truthful results, but he who employs them must know if the premises are true, and only a critical clinician can tell if the instrument is employed under the conditions that supposedly are present. A simple instance of this kind is the use of the sphygmomanometer. We compress the brachial artery by pneumatic pressure that is measured by a mercury column. What could be simpler or apparently more dependable than those factors of air pressure and the weight of a measured column of mercury? Not many years ago an eminent surgeon who was discussing the modern progress of medicine said, "Now that we measure blood pressure, what has become of the tactus eruditus that was the boast of skilful physicians in former years?" By way of retort the same question may be asked in refutation of his argument, for without control by the tactus eruditus the blood-pressure instrument is a very undependable device. I have heard very good clinicians say that palpation of the pulse is no longer of service since we can measure the maximum and minimum arterial pressure. It should rather be said that since we pretend to measure blood-pressure it is more needful that we should cultivate the art of arterial palpation to avoid the pitfalls of the instrument. And so the same argument can be amplified by saying that supposed precision of all laboratory information demands a more diligent cultivation of the bedside art to escape the tricks these devices play us. On the other hand, nothing will more enlarge, adorn and enrich the clinician's point of view than to employ laboratory devices in the solution of clinical problems.

To flourish and develop the clinician needs rich and various sources to feed his mind. No man is creative enough to invent his own requirements in sufficient quantity. For this reason no man can afford to live on his own ideas. All must shrivel who live within their own world, no matter how large it may be. The zest for curiosity that exceeds the bounds of one's own activity must be cultivated or ossification will follow. By such a statement it is not meant that all clinicians to grow must work in laboratories, for there are men who throw themselves into the midst of busy practice, gather new knowledge and grow wise in medical philosophy without entering a laboratory or mastering its methods. But there is a great difference between retaining contact with practice and becoming its victim. If in the midst of practice one spends all his time in devising methods for his patients' comfort, or what is still more likely, if he becomes the victim of practice and spends his time in tittle-tattle and serves the prejudices of his patients rather than educates them, he will in a few years dry up the sources of mental life and lose all creative desire.

There is one kind of clinician who has become submissive in the presence of laboratory reports. He resigns his art in the face of instrumental devices and does not employ the information gained from both sources. For reciprocal criticism, each point of view should rein the other to obtain the best results. I am quite sure that I have been criticized as old-fashioned and reactionary, not because I have failed to welcome information from laboratory sources, but by reason of the fact that I have always urged medical students to retain a grasp on the art of diagnosis and never submissively to accept a laboratory report without submitting it to strict clinical criticism. The kind of practice I have disparaged is to measure blood-pressure without previously analyzing the character of a pulse and estimating the pressure with the fingers, or to have an X-ray picture made of the thorax and then examine the patient. If one examines a thorax after the X-ray picture is seen, he is very prone to make his examination conform to the interpretation of the Roentgenogram. Or with a patient complaining of symptoms that are not readily explained to make a Wassermann test and on this test alone accept or reject a diagnosis of syphilis. Or in the presence of fever and suspicious cardiac symptoms, to base the presence or absence of endocarditis on the results of bacteriological blood cultures

or an agglutination test. Such practices are fatal to the cultivation of a refined clinical art. Such methods lower the art and dignity of a diagnostician to that of a conductor of tests. It reminds one much of the methods employed in the ecclesiastical courts of a few centuries past, where tests instead of evidence were employed to determine if the accused were guilty of witchcraft.

We should be wary of all tests that can not be incorporated in the sum of evidence. A test is not evidence but a touch-piece that becomes a standard or criterion for discovering the nature of disease. Such devices are welcomed because they relieve the need of mental effort. What are we to do when tests and collected evidence conflict? Obviously the thinker will abide by the evidence and the tester by his fetish.

The same complaint about the very modern tendency of clinical men to depend too exclusively on laboratory data is heard from laboratory men as well as from reproving senior members of the clinical side. Roentgenologists say that patients are referred to them with the general request to search with the X-ray for evidence of disease. And those who conduct microscopic and chemical laboratories complain of a want of clinical information for guidance in their work.

Microscopic, chemical and bacteriological endeavors that have no burning clinical needs or clinical concepts behind them are likely to be made with the spirit of factory standardization rather than with intelligent investigation. There are, of course, certain standardized laboratory tests that can be done satisfactorily by trained technicians and should be done by them, for they are not worthy of the time of a more broadly trained professional; but to centralize all laboratory work with the idea that better and unprejudiced skill is employed in such work is an error. To be prejudiced means that judgment precedes the known facts. This must be the mental attitude in all investigations. Had Pasteur had no convictions about spontaneous generation before the facts were known, would he have become the father of the science of bacteriology? Certainly prejudice must precede discovery or there will be little heat to bestir investigation. Conviction supported by fancy and conviction guided by intelligent criticism with reverence for the truth are two contrasted statements that describe two classes in the whole mass of investigation, the one ephemeral and the other permanent.

Specialization is very apt to mean contraction of mental field, and medicine is as broad as all the collected fields of biology. It has often been argued that to compare the collective efforts of many specialists with that of one broadly trained man is like comparing a mosaic with a painted picture. The simile is unfortunate and superficial, for the mosaic is a fragmentation of a constructed picture, and to reverse the process by constructing diagnoses out of fragmental views multiplies the dangers, because each fragment is a potential source of error.

Within very recent times there has come from highly credited sources a doctrine that inasmuch as the art of diagnosis has grown out of the sum of knowledge of physics, chemistry, physiology, anatomy and pathology, therefore one who is trained in these subjects possesses the components of clinical medicine and needs only a brief exercise of this collected knowledge in the clinic to become a clinician. This is an unfortunate error, for it has led to placing immature men in posts of clinical responsibility which they can never fill with credit, not because they want intelligence but because they have not spent sufficient time under the guidance of superior clinical skill. From one university we hear the complaint that they want "professors of medicine and not guinea-pig professors." In another university I have observed a ward class spend the entire morning in listening to a recital of the failure and successes of laboratory tests and hearing nothing about the many highly instructive and illuminating physical signs that should have occupied the teacher's time and must be learned by students if they master the logic of the clinic.

Such teaching methods waste the students' time, and are about as stimulating to mental effort as counting fingers or shuffling cards.

This criticism does not carry with it a denial of the great value of many laboratory methods, but it does condemn the neglect of direct observation which is apparent in some educational centers where the laboratory studies have superseded rather than illuminated clinical methods. The advancement of the laboratory should stimulate, not inhibit, bedside acumen.

Wherever laboratory technique thrives and physical diagnosis declines there is a poor school for medical students.

The very modern fashion to exalt the laboratory and lower the efforts in clinical studies has given rise to a criticism of medical education that frankly offers to lower our educational standards by eliminating a large part of the pre-clinical laboratory work that supposedly has taken the students' interest away from the patient.

To me it seems indisputable that if a keen bedside observer engages in laboratory experiment or in the use of instruments of precision to explain or confirm his clinical conceptions, it can lead only to accuracy

in physical diagnosis and sharpened bedside perspicuity.

If instruments of precision supplant physical diagnosis, there is an obvious confession of diagnostic weakness. If science dulls our wits, then we own a witless science. This has actually occurred in some schools where teaching chairs are occupied by immature clinicians whose diagnostic training has lagged behind their laboratory skill.

Instruments of Precision

The blood-pressure apparatus is one of the most useful instruments that have been devised for diagnostic aid, and it is so simple and generally so dependable that it has not only come to be regarded as indispensable but it has opened such a quick and easy way to gain important information about the pulse that the cultivation of the tactus eruditus has fallen into neglect.

There remain in the pulse many things to be learned that only the learned touch will reveal, and should the tactus eruditus be ignored, the blood-pressure apparatus will often leave us not only ignorant but misinformed. The blood-pressure instrument is sometimes misinforming when a hypertonic brachial artery offers high resistance to the compressing cuff so that the arterial pressure as measured in the arm may be 250 mm Hg and in the leg 100 mm less—obviously a gross error that can not be detected without the tactus eruditus that in some quarters is quite abandoned.

Unless the blood-pressure as measured in the arm by the instrument conforms to our estimate by touch of the femoral artery, we should not accept its readings. Usually the two methods give the same results; when they do not, judgment should be suspended until the source of the disparity is explained.

For records the instrument is absolutely necessary, but if uncontrolled by the touch it may often lead us into great error in estimating the hydraulics of blood flow.

It should be remembered that when we estimate the blood-pressure by the finger, we perceive the concrete phenomenon of bursting tension and not the more abstract factor of hydraulic pressure. Bursting tension is equal to the arterial diameter multiplied by the pressure, and therefore, the pressure remaining the same, the bursting tension varies directly as the arterial diameter. In a large artery like the femoral, in which the diameter varies little with vascular hypertonus, we have an unvarying multiplication of the pressure, which does not obscure the changes in pressure when increased and diminished. If the pressure in the radial or brachial is doubled at the same time the diameter is halved, the bursting tension is unchanged and therefore a rise in pressure escapes manual detection. This is a very simple principle in physics that was not applied until after the blood-pressure instrument was employed, so the tactus eruditus is not superseded by the instrument but has become more learned and more essential because it saves us from instrumental error.

The best service a sphygmomanometer can render a doctor is to teach him how to estimate blood-pressure with his fingers. If it has not taught him how to do this, then he is at the mercy of a witless instrument.

The sphygmograph was originally employed to detect modifications in the anacrotus and katacrotus. The results of the instrument can not be accepted unless confirmed by the touch. The instrument is now used to portray graphically what we perceive by touch, and there is no better method for educating the touch than to confirm it by the instrument. But the tactus eruditus must always be the arbiter where there is any question of interpretation. To say which is the better method is much like arguing on which hand holds the soap or which hand washes the other. Both hands are essential to obtain the best results.

One of my students when visiting a hospital in another city was critically palpating a patient's pulse when the chief told him that in that clinic they had given up trying to gain information by pulse sensations in the face of instruments of precision, and casually observed that the ancient Chinese were the only persons who had satisfying success in interpreting the pulse with the fingers. This observation is quoted because it shows how little one may profit by the use of instruments of precision.

The electrocardiograph is one of the most refined and exquisitely working pieces of mechanism that have been devised for clinical studies. The auriculo-ventricular activation is revealed with astounding clearness, and yet it is possible in most cases to predict what the electrocardiogram will reveal if we carefully determine the relative chronicity of the auricular and ventricular beats by observing the venous and arterial pulses. There are some cases in which this time relation between activations of the auricle and ventricle can be determined only by the instrument, but the instrument should teach a careful observer so that he may learn to dispense with it. It is dangerous to employ aphorisms in the service of science, but it is approximately true that any instrument of precision is of little value that does not teach us enough to dispense with its use.

THE X-RAY DIAGNOSIS OF CARDIAC AND PULMONARY DISEASES

Any criticism from an internist on the use of the X-ray that may be interpreted as detractive would sound ungrateful. No internist who had his training prior to the Roentgenogram should fail in gratitude for its aid and for its many contributions of direct evidence in problems for whose solution we formerly depended on logical interpretation. The Roentgenogram is only a silhouette of structures quite hidden from our view, and it can not pretend to think or supply evidence for any other attributes than those which form the silhouette, and in many instances of heart and lung pathology, even the silhouette is incomplete. Like the blood-pressure instrument, the interpretation of the Roentgenogram requires intelligent criticism, and this criticism must be based on evidence that is gathered from a history and complete physical examination. The X-ray should greatly stimulate and aid us in the cultivation of the art of physical diagnosis and not supplant the art as too often occurs. The X-ray evidence is pictorial and therefore satisfying to the uncritical, but photographic evidence very often suppresses a desire for procurable evidence that may refute what seems to be an obvious proof.

A disallowable practice is to use the X-ray as a preliminary step in diagnosis. The physical examination should first be carefully made, and then if the evidence is incomplete, a Roentgenogram may be made, and if need be in face of it the physical examination repeated and revised. But if a physical examination is made with the Roentgenogram in view, it will so strongly prejudice our findings that little will be learned from the examination. If physical examinations are made to confirm the X-ray picture, little progress is made in the diagnostic art. I have visited university clinics where much effort was expended in analyzing X-ray pictures, as if there were no other method of gaining information, for not a word was said about the results of inspection, palpation, percussion or auscultation.

Such practices are very misleading to medical students, who like all humanity are disinclined to use much effort where an easier way seems to offer a solution. Let them have unrestricted liberality in the provision of X-ray pictures and little real effort will be employed to learn the difficult art of physical diagnosis. If the student is not taught that he should endeavor to predict what the X-ray will show, he will become the servant of an instrument and not its master.

The contour of the lateral and upper boundaries of the pericardial sac is accurately revealed by the X-ray, but the inferior border and the inferior aspect of the heart are hidden in the nest of the central tendon of the diaphragm. A clear conception of this view of the heart is essential for the formation of a clear idea about protusion of a distended pericardial sac in a ventral direction, and it is also essential to gain a clear mental picture of the size of the two ventricles and the right auricle.

Cardiac diagnosis is incomplete unless we can form very definite ideas about the size of the left and right ventricles and the right auricle. The Roentgenogram does not give us as clear evidence for estimating the relative volumes of the heart's chamber as can be gained by a careful physical examination. Nor can the X-ray give us as clear a conception of the relative disabilities of the two ventricles as a careful examination will reveal. When we have learned the size of a ventricle, we have made only partial progress toward an evaluation of the heart's disease. Slight enlargement of the left ventricle in many cases of arterial sclerosis will be overlooked if only X-ray pictures are used to estimate its size. The hypertrophy of the right ventricle will also be underestimated in many cases of mitral stenosis and disease of the pulmonary arteries.

The significance of cardiac enlargement in arterio-venous fistula can not be rightly interpreted from an X-ray silhouette.

The X-ray gives us no information on the ventricular diastolic systolic excursion, which by physical examination can be plainly shown to be increased in arterio-venous fistula and also in Graves' disease.

Whenever the third, that is, the antero-posterior dimension of the heart of pericardium, is needed or the inferior or ventral aspect of the heart or pericardial sac is in question, we must depend on physical examination. If we depend on the X-ray to detect early syphilitic disease of the arch of the aorta, the diagnosis will as a rule be made too late to render aid by specific treatment.

In the study of pulmonary disease we find the X-ray of very little aid and often misleading when we try to detect incipient tuberculosis, or to gauge the activity of disease known to be present, and also in all diseases of the thorax that lie behind the phrenic dome. The X-ray fails, of course, because this region is obscured by the shadow of the diaphragm. For this reason subphrenic abscesses, abscesses at the bases of the lungs and sacculated pleurisies must all be detected by physical examination.

These outstanding and frequently occurring problems in diagnosis are mentioned as those in which the X-ray gives no aid or may be very misleading, but

there are, of course, many cases of intrathoracic disease in which the X-ray is of great service, and there are also some lesions that can not be diagnosed without its aid. The criticism is not made on the use of the X-ray but against excessive dependence on its services.

In the study of cardiovascular and renal disease, we often see voluminous laboratory reports on chemistry of the blood and urine when they belie clinical evidences that are undebatable, or confirm by a laborious and expensive process what can be learned with sound economy of labor and money by a competent physical examination. It is not pleaded that such studies have no investigative value, but that they often serve to impress the uninformed laity as a clinical diagnosis based on the accuracy of mathematics and quantitative chemical estimates that supposedly should surpass clinical judgment. And it is not only the wholly uninformed laity who are thus deceived, but often the clinician is quite contented to rest his diagnosis and prognosis on deductions made wholly from such sources.

The same criticism might be prolonged into a discussion of the disappointments of clinical microscopy and clinical bacteriology. Evidence from such sources is often final and may be all we can get on which to rest a diagnosis, but such sources of information do not justify neglect of critical physical examinations. The service of the laboratories and instruments of precision are comparatively new in medicine, and some of their revelations have been so satisfying that there has been a growing tendency to supplant diagnostic effort with the employment of tests and touch-pieces. In America our proverbial enthusiasm for efficiency, standardization, factory methods and mechanistic devices has led us to weaken our cultivation of the art of diagnosis. This is only temporary; it is a transient phase of the development of medicine in America that is more accentuated than elsewhere. It would not cause any concern if this view of medicine were found only among practitioners who employ these devices to support their drooping diagnostic skill, but it is a manner of thinking that has found its way into many educational institutions where men are prepared for medical practice. It has become apparent in the programs of many of our medical societies, where attention seems to have been withdrawn from the art of medicine and devoted too largely to the cultivation of technical devices and laboratory research that has little to do with the advancement of diagnosis or treatment. A year ago, while visiting a distinguished foreign clinician who had been engaged in visiting all the centers of medical teaching in America, I was told by him that he was greatly pleased with the effort at laboratory investigation in this country, but he said, "Everywhere I went I was presented with a great lot of evidence from the laboratory, but information or interest in the physical findings on the patient were notably wanting. It seems to me that in your enthusiasm for the pursuit of laboratory evidence you have forgotten the patient."

It is not advocated that we should lessen our endeavors in the laboratory, but that we must not slacken our efforts at the bedside. Men are imitative in their methods, so that fashions in thinking gain their vogue just as do styles of millinery. And styles of thought are slowly adopted or abandoned. Much time may be lost by an errant style of thinking that will prove very costly in the intellectual development of our profession.

In recent years the way of the laboratory has provided a speedy approach to clinical chairs because the evidence for accomplished laboratory work is exhibited to so much better advantage than evidence for clinical observations. Graphic records provide evidence that has all the advantage of the pictorial method, mathematical tables provide visual evidence for acumen and diligence, and the employment of touch-pieces provides statistics that disarm all but the very critical skeptics. These devices afford a tangible method for appraising work that admits of classifications. The candidates can be ranked in the order of their productions and the method allows an approximate estimation of industry which is certainly an estimable virtue, but the evidences for the more subtle merits, intelligence, originality and truthfulness, can not be measured and weighed. Many years ago a professor of the University of Vienna said, "The method of choosing teachers for advancement is based on the avoirdupois of their publications. So that now our faculties are classified like our artillery into one-pounders, five-pounders and ten-pounders." If this mode of thinking has taken possession of our teachers and leaders in medical thought, should we wonder that lesser lights in the profession and also the laity are being led by such computable pleadings?

In conclusion, let it be understood that I do not direct criticism against laboratory methods. I do not wish to undervalue them, or wish to see our students spend less time in laboratories. ***All laboratory tests and technical instruments have been devised to explain problems or to answer inquiries that have been raised by inquiring physicians.*** If the results serve to slacken our cultivation of the diagnostic art instead of to sharpen our clinical insight, then the present-day medicine is in need of a renewal of the

spirit that guided some of our older clinicians who never wasted their time in laboring for things beyond their reach, but who carefully and minutely studied every perceptible evidence that lay within the ken of their senses.

I have been led to offer these criticisms on a tendency in American medicine because a common complaint from physicians is their want of laboratory facilities. Often they are heard to talk as if their professional happiness would be complete if they had at their command an ample laboratory with abundant technical service. Such complaints are due to a want of cultivation of the seeing eye and sensible fingers. The exercise of intelligent clinical observation should be to a physician the most fruitful source of intellectual satisfaction. In this kind of work he can always gather new knowledge by employing originality, and he must be original to do it. Such work is more satisfying than to repeat tests which have been devised by the originality of others. A photographer derives some pleasure from a photographic reproduction of a painted picture, but how inferior is such pleasure compared with that of the original painter. When a complaining doctor leans too heavily on laboratory support for comfort in his practice, it probably means that he has failed to strengthen the powers that lie within his grasp. When by his perspicacity a doctor makes a diagnosis of an obscure case he has a glint of the same divine fire that lit the mind of Democritus when he said, "Rather would I explain the cause of a single fact than become king of the Persians."

OBITUARY

THE SCIENTIFIC WORK OF ETIENNE S. BIELER

BEFORE me are some original papers on a variety of scientific subjects published in British, Canadian and American journals—a noteworthy contribution from the pen of a deeply mourned friend and colleague cut off in the prime of his scientific activity and production. Etienne Bieler gave early proof in the advanced mathematical classes at McGill of a singularly lucid and penetrating mind and a power of concentration which his teachers felt assured would place him in the front rank of scientific men of his time. He was marked out for a career of distinction in the field of physics, and during his final years of study in Montreal covered a consistently broader range of studies than is usual. The writer well remembers in the spring of 1915 Bieler's announcing his decision to enlist in the McGill University Company, and immediately afterwards commencing to write a difficult examination in applied mathematics, in which he took brilliant marks. Returning invalided from France in 1919, he joined the postgraduate classes with a view to proceeding to his M.Sc. degree—a part of the work being taken in electrical engineering, in order to add a certain amount of breadth to a future career in pure science.

A class problem was the source of Dr. Bieler's first published paper. At that time methods had been successfully worked out in Great Britain for detecting submarines by their disturbance of the earth's magnetic field reacting on a loop of submarine cable. The complete solution of this problem was at a later date written up and communicated to Sir William Bragg, for use of the Admiralty. It was later released for publication and published in *Proceedings* of the Royal Society.[1]

[1] October, 1921.

It is impossible in a short article to do more than select a few papers describing Bieler's most important contributions to science. Passing over a short paper on the "Measurement of Small Capacities" (1921), giving in abstract the results of a highly creditable thesis on the distribution of electric potential across the suspension insulators used in high voltage lines, I turn to a paper published in the *Transactions* of the Royal Society of London (1924), dealing with the scattering of α-particles by light atomic nuclei. It is now well known as a result of Sir Ernest Rutherford's investigations that an atom consists of a central nucleus carrying a positive electrical charge about which are rotating a greater or lesser number of electrons or ultimate electrical particles of negative electricity. On arriving at the Cavendish Laboratory as 1851 exhibitioner, Bieler was assigned the task of investigating the nature of the electric fields in the neighborhood of nuclei of light atoms such as aluminum and magnesium. The experiment consists in firing α-particles (positively charged helium atom) from radium into a thin screen of the metal to be investigated. The deviation of α-particles passing at various distances from the atomic nuclei may be detected by the scintillations which are produced in a zinc-sulphide screen. The experiments are exceedingly laborious, as scintillation counts can not be made otherwise than by the naked eye, which must be rested at frequent intervals to be able to detect the faint effects observed. The theoretical aspect of the subject is considered in a page published in the *Proceedings* of the Cambridge Philosophical Society (1923), and there is evidence of high and mature mathematical power on the part of the author. The final result shows that the nature of the nuclear field begins to deviate from the "inverse square law" at a distance of 10^{-13} centimeters. The scientific results

we have just described are often quoted in the literature of the atom as a tribute to the fundamental nature of the work.

On returning to McGill as assistant professor, Bieler continued his work along similar lines, but was greatly handicapped by the lack of a suitable supply of radium, curiously enough in the very laboratory where its essential properties were first discovered. He then turned his attention to magnetism, and in preparation for an attack on the experimental side of the subject published a critical survey of the subject in the *Journal* of the Franklin Institute (1927). In collaboration with Mr. C. T. Lane, the technique for obtaining samples of extremely pure substances was developed, and the determinations made in the McGill laboratories are now quoted as among the most reliable.

In the summer of 1927 Bieler developed, in collaboration with Mr. H. G. I. Watson, a new method for geophysical prospecting which was successfully applied in the mining districts of northern Quebec. A brief account of his work is published in the *Canadian Mining and Metallurgical Bulletin* (1928), just before the author left to take charge, under the auspices of the Australian government, of an extensive program of work planned to locate, if possible, new mineral deposits. There is no doubt but that, had Bieler lived, he would have been among the foremost world authorities in this field. An appreciation of his work in England and in Australia by his coworkers there, will, it is to be hoped, appear in another issue.

He died at Geraldton, western Australia, on July 25, 1929, after a brief illness of acute pneumonia.

I have spoken only of Bieler's scientific work. He was equally at home in writing and speaking French and English, and it has several times been my privilege to hear, among a group of friends interested in literature and music, articles from Bieler which testify to a vivid imagination, an extensive vocabulary and an inside knowledge of the works of literary men.

L. V. KING

McGILL UNIVERSITY

HENRY CHAPMAN MERCER

DR. HENRY CHAPMAN MERCER, an archeologist and ethnologist of international reputation, died at Doylestown, Pennsylvania, on Sunday, March 9. Many generous bequests of scientific interest were made in his will. The famous Mercer Museum, erected and maintained by Dr. Mercer for the Bucks County Historical Society, has been bequeathed to that society and endowed with a maintenance fund of $130,000. The Mercer Museum contains a historical collection, which is internationally famous, of some twenty thousand ethnological tools and implements of the pioneer settlers of America. Fonthill, Dr. Mercer's incomparable home, is bequeathed to the public for a museum, and the beautiful grounds surrounding it are given to the Doylestown Nature Club as an arboretum, both bequests to be maintained by an endowment fund of $100,000. Another $100,000 bequest is made in memory of his uncle, Timothy Bigelow Lawrence, to Rudolf P. Hommell, Lehigh University, who now is conducting an expedition in the Far East for the collection of utensils employed in the daily life of the inhabitants.

Dr. Mercer was never married. He was born in Doylestown, Pennsylvania, on June 24, 1856. In 1879 he was graduated from Harvard with the degree of A.B. Dr. Mercer received the honorary degree of doctor of science from Franklin and Marshall College in recognition of his archeological discoveries during his Yucatan expedition. He was granted the honorary degree of doctor of law by Lehigh University. Principal among several honors bestowed on Dr. Mercer was the award of a bronze medal by the Exposition Historico-Americano Madrid in 1892 for his "Lenape Stone."

In 1882 he was an honorary member of the United States Archeology Commission at Madrid. He became editor for anthropology in the *American Naturalist*. In 1894 he was appointed by Dr. William Pepper as curator of American and prehistoric archeology at the University of Pennsylvania and filled that position until 1897.

Dr. Mercer had contributed numerous learned papers to historical publications and published many books. Among his books are "Hill Caves of Yucatan" (1896), "Antiquity of Man in the Delaware Valley and Eastern United States" (1897) and "Ancient Carpenters' Tools" (1929).

Fonthill, which was built by Dr. Mercer in 1908 and 1909, is a unique residence entirely of concrete with beautifully groined and arched ceilings, upon the interior of which Dr. Mercer lavished his finest exhibitions of ceramic art, illustrating history and historical subjects, both ancient and modern.

Dr. Charles Conrad Abbott wrote the following ode to Dr. Mercer:

Reincarnation of the storied past,
Skyward, in majesty, thy walls arise,
In strength assuring us that they shall last;
Not crumble as the common structure dies.
Thy towers, mantled with the morning light,
Proudly acclaim the past is still alive
Where proud, grim feature, or the sorry sight,
Would have the world in soulless fashion thrive.

All honor then to him who raised the pile;
Where daydreams wander through each classic room;
Where honest speech is never brought to trial,
Nor trustful candor hear its certain doom.
Defying critics, faithfully thou wrought—
Thou master builder of a fruitful thought.

ALBERT MOYER
NEW YORK CITY

SCIENTIFIC EVENTS

THE KEW BOTANICAL GARDENS[1]

FOR the public Kew is a delightful pleasaunce, for the gardener a demonstration of achievement and a suggestion of possibilities, and for the botanist a storehouse of information and a center for research. The recently issued number of the *Bulletin of Miscellaneous Information* (Appendix I., 1930), comprises under this familiar but somewhat unattractive title a review of the work of the various departments of the Royal Gardens during 1929. In 1925 work was begun on the formation of a National Pinetum at Bedgebury, in Kent, as the nearness of London is not conducive to the growth of conifers; and in spite of the long cold winter and abnormally dry summer of 1929, good progress is reported. The abolition of the penny charge for admission to the gardens from August Bank Holiday onwards is reflected in an increase in the number of visitors of nearly 220,000 between August and December, as compared with the corresponding period in 1928. The hard winter of 1928–29 and the boisterous gales of the last two months of the year caused severe losses among shrubs and large trees, but the long hot summer gave an unusual brilliance of color to the abundant crops of fruits and berries on many of the trees, and the later incessant and heavy rains effectively cleansed trees and shrubs from soot and dirt.

The more strictly botanical activities of the Royal Botanic Gardens, Kew, have benefited by generous grants from the Empire Marketing Board, which have rendered possible visits by the scientific staff and various collectors to different parts of the empire overseas and elsewhere, resulting in valuable accessions to the gardens and herbarium, and the gain of invaluable experience to individual members of the staff. Mr. Hutchinson's botanical tour in South Africa produced a harvest of more than 3,000 species, including a large number of living succulent plants. Work of botanical exploration has also been carried out in British Guiana, Persia, Somaliland and the Solomon Islands. Considerable additions have been made to the herbarium, mainly by the incorporation of stored material. An important feature of the work is the international cooperation in research rendered possible by an extension of the system of reciprocal loans between important botanical institutions; during the year more than 9,000 specimens were borrowed and nearly 6,000 sent out on loan. Botanical work in South Africa will be greatly facilitated by an arrangement to present to the National Herbarium at Pretoria duplicates of authentic specimens in the Kew Herbarium. The report of the museums records an increasing interest taken in the economic products of plants, involving much correspondence and discussion of home and colonial products with visitors. The difficulty in answering questions as to possibilities of new crops for home or the colonies is often enhanced by the lack of discretion on the part of optimistic journalists.

[1] *Nature.*

SUMMER SCHOOL FOR TEACHERS OF ENGINEERING

THE Society for the Promotion of Engineering Education in conjunction with the Carnegie Institute of Technology will conduct a summer school for engineering teachers beginning on June 12 and ending on June 21. The session this summer will be devoted to engineering drawing and descriptive geometry, and will be held on the Carnegie campus.

The summer school is an enterprise growing out of the general investigation of engineering education conducted by the Society for the Promotion of Engineering Education. Its general purpose is the improvement of the teaching of engineering. Each session is devoted to the study of methods of teaching a particular subject of the engineering curriculum.

William E. Mott, director of the College of Engineering, and Harry M. McCully, professor of drawing and descriptive geometry at the Carnegie Institute of Technology, are local director and secretary, respectively, of the summer course. Thomas E. French, professor of engineering drawing, Ohio State University, will be chairman of the teaching staff.

The nine-day session will begin with an address of welcome by Mr. John L. Porter, chairman of the trustees' committee of the Carnegie Institute of Technology. The various meetings will be conducted by teachers who are recognized as leaders in their fields. Entertainment features, including a smoker given by the Engineers' Society of Western Pennsylvania, will be arranged during the session. Trips to the larger Pittsburgh industrial plants have been planned.

Professors from schools in all parts of the country and from Canada and Mexico will attend the meeting. Registration will be limited to a hundred teachers.

Besides those mentioned above, the teaching staff will include the following: Franklin DeR. Furman, dean of the Stevens Institute of Technology; H. W. Harold, architect, Pittsburgh; Frederic G. Higbee, the State University of Iowa; Randolph P. Hoelscher, University of Illinois; George J. Hood, University of Kansas; Harvey H. Jordan, University of Illinois; A. E. Lofberg, Westinghouse Electric and Manufacturing Company, East Pittsburgh; Clair V. Mann, Missouri School of Mines; Henry W. Miller, University of Michigan, and author of the recent book on the famous German gun "Big Bertha"; P. J. Reich, American Bridge Company, Ambridge, Pa.; Robert L. Sackett, dean of the School of Engineering, Pennsylvania State College; Charles H. Schumann, Jr., Columbia University; William G. Smith, Northwestern University; Carl L. Svensen, Texas Technological College; William D. Turnbull, the Ohio State University; Frank M. Warner, University of Washington, and William E. Wickenden, president of the Case School of Applied Science.

The summer school is under the immediate direction of Harry P. Hammond, head of the department of civil engineering, Brooklyn Polytechnic Institute. Professor Frederic L. Bishop, of the University of Pittsburgh, is secretary of the society.

AWARD OF THE DANIEL GUGGENHEIM MEDAL FOR AERONAUTICS

THE second Daniel Guggenheim gold medal for notable achievement in aeronatuics has been awarded to Dr. Ludwig Prandtl, professor at the University of Göttingen, Germany, "for pioneer and creative work in the theory of aerodynamics." Dr. Prandtl is one of the world's most eminent authorities on aerodynamics and other sciences underlying the art of aviation. He is also well known as an investigator and teacher of the laws of mechanics, thermodynamics and the flow of fluids, particularly air and other gases.

Last fall, Dr. Prandtl traveled eastward from his home city as a delegate to the World Engineering Congress in Japan at the end of October and the beginning of November. He presented an important paper at this congress. After the congress, he crossed the Pacific Ocean to the United States. He stopped at a number of our universities on his homeward journey, beginning with Stanford University and the University of California. He returned home in March, completing the trip around the world.

Dr. Prandtl visited New York in February and on that occasion was entertained at dinner at The Engineers' Club by a group of forty American engineers. Following the dinner he delivered an address before the Metropolitan Section of The American Society of Mechanical Engineers. Dean George B. Pegram, of Columbia University, presided at the dinner. Dr. Elmer A. Sperry, past-president of The American Society of Mechanical Engineers and vice-president of the Daniel Guggenheim Medal Board, introduced Professor Prandtl on the occasion of his address.

Dr. Prandtl was born on February 4, 1875, at Freising, Germany, and attended the technical high school in Munich. He has been professor at the University of Göttingen since 1904. He has received many honors, among them the Great Gold Medal of the Royal Aeronautical Society of England in 1927 and the Grashof Medal of the Verein Deutscher Ingenieure in 1929. More than any other one man he stands out as the "father" of the present aerodynamic theory. He has written many treatises on subjects related to aviation and is a widely respected authority.

The members of the board which made the award are: *American*—W. F. Durand, E. P. Warner, Elmer A. Sperry, Arthur Nutt, Howard E. Coffin, Paul G. Zimmermann, E. E. Aldrin, Emory S. Land; *Foreign*—Griffith Brewer, England; Johann Schuette, Germany; Giulio Costanzi, Italy; Baron Chuzaburo Shiba, Japan. Dr. Rateau, of the Société Française de Navigation Aerienne, died before the ballot was cast.

The first award of the Guggenheim Medal for notable achievement in aeronautics was made to Orville Wright a year ago and the medal was presented to him in Washington on April 8 in connection with the celebration of the fiftieth anniversary of The American Society of Mechanical Engineers. This society is one of the two American organizations from which members of the Medal Corporation are chosen, the other being the Society of Automotive Engineers. In addition, five foreign organizations are represented on the board of award, one each in England, France, Germany, Italy and Japan.

The medal was founded in 1927 by the Daniel Guggenheim Fund for the Promotion of Aeronautics, of which Mr. Harry F. Guggenheim, now ambassador to Cuba, was then president. At the annual meeting on May 7 the following officers were elected: *President,* William B. Stout, representing the Society of Automotive engineers, president of the Stout Air Service; *Vice-President,* Captain E. E. Aldrin, manager, Aviation Department of the Standard Oil Development Company; *Secretary* and *Treasurer,* Alfred D. Flinn, director of the Engineering Foundation; *Executive Committee,* the president, Captain Aldrin and Mr. E. P. Warner, editor of *Aviation.*

A. D. F.

THE RETIREMENT OF THE PRESIDENT OF THE UNIVERSITY OF CALIFORNIA

PRESIDENT WILLIAM WALLACE CAMPBELL, who, on commencement day nearly one year ago, announced

that he purposed to retire from the active service of the University of California 14 months later, on July 1, 1930, will resume his residence on Mount Hamilton, following his retirement from the presidency of the university three months hence.

William H. Crocker, chairman of the board of regents, by the authority of the regents, recently extended to President Campbell the invitation of the board that he continue to serve as director of Lick Observatory and as an astronomer in Lick Observatory from and after July 1, 1930, and until, two years hence, he should attain the age of seventy years.

President Campbell was unable to accept this valued invitation to remain in active service, with responsibilities for the directing of the observatory and for the continuous pursuit of astronomical research as an active astronomer. He felt that his decision, as publicly announced in May, 1929, was a wise one; but he informed the regents through Chairman Crocker that he would be greatly pleased to continue his residence on Mount Hamilton, with principal purpose to renew his astronomical studies and to continue them so long as his physical health and mental vigor should justify.

It has been in accord with his most ardent desires that he possess the privilege of taking up again his astronomical work at the Lick Observatory, under the auspices of the University of California. The regents accordingly, and by unanimous vote, determined that following his retirement on July 1, 1930, he should bear the titles, president emeritus of the University of California, director emeritus and astronomer emeritus of the Lick Observatory.

The regents further invited President and Mrs. Campbell to occupy the residence on Mount Hamilton which was built for them in 1894, and in which they resided continuously from that date until they came to the president's house in Berkeley in 1923, and to which in the past seven years they have frequently returned for short stays. However, and largely in consequence of their period of residence in the mild climate of the Berkeley campus, they will probably not be in actual residence on Mount Hamilton during the winter months, where the storms are frequently severe.

AWARDS OF THE FRANKLIN INSTITUTE

THE medal meeting of the Franklin Institute, Philadelphia, will be held on the afternoon of May 21. On this occasion honorary membership will be conferred on Dr. Mortimer Elwyn Cooley, dean emeritus of the College of Engineering of the University of Michigan, and on Dr. Henry Leffmann, of the Franklin Institute. The Certificate of Merit will be presented to Heyman Rosenberg, of the Parker-Kalon Corporation, New York City. Medals will be presented as follows: *Longstreth Medals* to Ervin George Bailey, Fuller-Lehigh Company, Fullerton, Pennsylvania, and to Charles Weyl, assistant professor of electrical engineering, University of Pennsylvania; the *Wetherill Medals* to Charles Sumner Chrisman, West Chester, Pennsylvania, and to William Nicholson Jennings, Philadelphia, Pennsylvania; the *Levy Medal* to Dr. Floyd Karker Richtmyer, professor of physics, Cornell University; *Henderson Medals* to George Hannauer (posthumous award), represented by George Hannauer, Jr., Chestnut Hill, Massachusetts; Edgar Marvin Wilcox, Hannauer Car Retarder Company, Gibson, Indiana; the *Clark Medal* to Henry Latham Doherty, Cities Service Company, New York City; *Cresson Medals* to Norman Rothwell Gibson, The Niagara Falls Power Company, and to Irving Edwin Moultrop, The Edison Electric Illuminating Company, Boston; the *Franklin Medals and Certificates of Honorary Membership* to Dr. John Frank Stevens, former chief engineer of the Panama Canal, and to Sir William Henry Bragg, director of the Royal Institution of Great Britain. The two Franklin medalists will present papers. Dr. Stevens will speak on "A Momentous Hour at Panama" and Sir William on "The Meaning of the Crystal." A dinner in honor of the medalists will be given in the evening at the Bellevue-Stratford Hotel.

SCIENTIFIC NOTES AND NEWS

PROFESSOR EDMUND BEECHER WILSON, of Columbia University, and Professor Sir John Bretland Farmer, of the Imperial College of Science and Technology, have been elected honorary fellows of the Royal Microscopical Society, London.

DR. L. O. HOWARD, on the nomination of the Entomological Society of Washington, has been elected an honorary member of the Washington Academy of Sciences. This action was taken in recognition of his distinguished contributions to entomology, his intimate connection with scientists and scientific work in Washington and his services to the academy as member and officer since its foundation.

THE Trudeau Medal for meritorious service will be awarded to Dr. Henry Sewall, of Denver, according to an announcement made at the opening meeting at Memphis, Tennessee, of the convention of the National Tuberculosis Association.

THE Gary Medal awarded by the American Iron and Steel Institute was presented to Mr. Charles M. Schwab for his services to the iron and steel industry at a dinner given in New York City on May 9. Among the speakers announced were Dr. Michael Pupin, Dr. John Johnston, Charles W. E. Clarke, W. A. James, Dr. F. M. Becket, Charles McKnight, Lee H. Miller and Arthur D. Little.

THE occasion of the eightieth birthday of Dr. David Bryson Delavan, known for his work in laryngology, was celebrated on May 3 by a dinner given in his honor by the New York Academy of Medicine at which more than a hundred members were in attendance.

THE Boston Society of Natural History held its annual meeting at the museum building on May 7 when the following officers were elected: Charles H. Taylor, *president;* Nathaniel T. Kidder, Glover M. Allen and William M. Wheeler, *vice-presidents;* Clinton V. MacCoy, *secretary;* Augustus P. Loring, Jr., *treasurer,* and Thomas Barbour, Joseph A. Cushman, William L. W. Field, Laurence B. Fletcher, Frederic H. Kennard and John C. Phillips, *trustees.*

DR. LUDWIG KAST, of New York City, was elected president of the American Gastroenterological Association at the thirty-third annual meeting recently held in Atlantic City. Other officers elected are Dr. Clement R. Jones, of Pittsburgh, *first vice-president;* Dr. Burrell H. Crohn, New York, *second vice-president;* Dr. Charles J. Lucas, Louisville, *secretary,* and Dr. Thomas Wray Grayson, Pittsburgh, *treasurer.*

THE prize for the best paper on scientific instruments, other than optical, to appear in *The Journal of the Optical Society of America and Review of Scientific Instruments* during 1929 has been awarded to Dr. K. C. D. Hickman, of the Eastman Kodak Company Research Laboratory, for his paper, "On Some Vacuum Recording Gauges," which appeared in April, 1929. The committee of award consisted of Professor H. W. Farwell, *chairman;* Dr. H. C. Rentschler and Professor F. W. Loomis. The committee made honorable mention of two papers by Dr. R. V. Baud, of the research department of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, on "Experimental Methods of Studying Stress Distribution" and "Further Developments in Photoelasticity," which appeared in May, 1929.

THE Committee for Scientific Research of the American Medical Association has made a grant of $700 to Dr. E. Brand, research associate in chemistry, New York State Psychiatric Institute and Hospital, New York City, for further research on Cystinuria.

THE J. T. Baker Chemical Company Research Fellowship in Analytical Chemistry, mid-western division, has been awarded to Mr. A. C. Shead, now at the University of Oklahoma, who will work at the University of Illinois. Dr. I. M. Kolthoff, of the University of Minnesota, has been added to the committee administering the fellowship.

DR. AUSTIN M. PATTERSON, professor of chemistry in Antioch College, was elected vice-president of the college at the annual meeting of the board of trustees on May 2.

DR. ARTHUR E. RUARK, at present physicist with the Gulf Production Company, has accepted a professorship in the department of physics of the University of Pittsburgh beginning next September to succeed Dr. J. J. Weigle, who leaves to take charge of the department of physics at the University of Geneva, Switzerland.

PROFESSOR WITHROW MORSE, who for the past seven years has directed the department of physiological chemistry and toxicology in the Jefferson Medical College and the work in chemistry of the Jefferson Hospital, retires from the chair and will devote his time to investigation.

MAX A. MCCALL, for the last six years assistant head of the Office of Cereal Crops and Diseases in the Bureau of Plant Industry, U. S. Department of Agriculture, has been named principal agronomist, in charge of this office. Mr. McCall has been acting in charge of the office for the last three months.

DR. LEON A. HAUSMAN, head of the department of zoology of the New Jersey College for Women, has been appointed consulting ornithologist for the experiment station. In this capacity Dr. Hausman will prepare a number of publications on bird life in New Jersey.

ACCORDING to *The Experiment Station Record,* Walter Toenjes, research assistant in horticulture at the Michigan Experiment Station, has been appointed superintendent of the Graham Horticultural Substation near Grand Rapids. Franklin Sherman, Jr., was recently appointed research assistant in entomology, *vice* L. G. Gentner, resigned, and Glenn L. Ricks assistant in horticultural research.

DAVID J. PRICE, Harry E. Roethe and Dr. Lawrence H. James, of the Bureau of Chemistry and Soils, U. S. Department of Agriculture, were named by Secretary Hyde to represent the department on a national committee to study spontaneous heating and ignition of agricultural products, which met in Atlantic City, N. J., on May 13, to formulate plans for and to correlate the various parts of a national research program for dealing with this subject. The committee included representatives of the Bureau of

Mines and of the Bureau of Standards in the Department of Commerce, and representatives of the fertilizer industry, the paint and varnish manufacturers, the feed manufacturers, railroads and steamship companies, insurance companies and other industries which handle stored products.

W. P. STEWART as head of the Virginia Weather Bureau Division has taken up his work as successor to the late Edward A. Evans. Mr. Stewart comes from Milwaukee and has been in the federal service for twenty-nine years.

DR. C. A. ELVEHJEM, of Dane County, Wisconsin, has been appointed to the staff of the department of agricultural chemistry at the University of Wisconsin. Dr. Elvehjem will return shortly from the University of Cambridge, England, where he has been spending the past year studying under a National Research fellowship.

DR. WILLIAM H. HOWELL, director of the Johns Hopkins School of Hygiene and Public Health, has sailed for Europe, where he will attend a meeting of directors of schools of public health in the United States and Europe at Geneva on May 20.

CLYDE C. WHIPPLE, assistant professor of electrical engineering at the Polytechnic Institute of Brooklyn, has been granted leave of absence for one year to serve as visiting professor in electrical engineering at the Green School of Engineering of Princeton University.

DR. LUCIUS H. MERRILL, professor of biological and agricultural chemistry at the University of Maine, has been granted leave of absence and will devote himself largely to his work as state geologist.

DR. C. B. FAWCETT, of University College, London, will be visiting professor in geography at Clark University during the fall semester of 1930–31. He will offer special work on "The Political Geography of the British Empire," and another series of lectures on "The Geography of Continental Europe."

PROFESSOR W. G. WOOLNOUGH, geological adviser to the Commonwealth government of Australia, is spending several months in the United States for the purpose of observing American methods and practices in the petroleum industry and in the administration and technique of official surveys.

DR. JAMES G. NEEDHAM, head of the department of entomology at Cornell University, has recently returned from a 5,000 mile airplane trip to the West Indies and the Guianas with thousands of specimens of dragonflies and their larvae, many of them new to science. In fifty hours of flying, during the two weeks he spent away from the university, Professor Needham visited regions which in the normal course of such an expedition would have required from two to three months to complete and would have entailed hardships and inconveniences which might well have made the trip an impossible one.

A WIRELESS dispatch to *The New York Times* from Adelaide, Australia, dated May 4, reports that Sir Douglas Mawson has announced that with the necessary funds in sight he is now organizing a second Antarctic cruise. He expects to leave Hobart, Tasmania, early in November with members of the staff of the ship *Discovery*. He intends to resume the scientific survey of the Antarctic and to cover an expanse of 1,500 miles lying between the meridian of 160 degrees east and the point farthest east which was reached on his last voyage. Part of this field came within the scope of his expedition of 1911–14. On the forthcoming voyage particular attention will be paid to fishery potentialities, including edible fish, seals and whales.

PROFESSOR DART, of the Witwatersrand University, has, according to the Johannesburg correspondent of the London *Times*, completed arrangements for joining an Italian scientific expedition on its journey through Equatorial Africa and the Nile Valley to Egypt and to Mesopotamia. The expedition is expected to elucidate the relationship between European and African fauna. Professor Dart will also endeavor to throw further light on the question as to whether man appeared first in Africa. The program of the expedition includes visits to the pygmies of the Ituri forests and to the Kivu gorilla country, as well as investigations at Zimbabwe. Professor Dart will examine independently the diseases prevalent in equatorial territories and the circumstances which young medical students might have to face in the equatorial regions.

THE University of Buffalo held its annual scholarship dinner on May 10. Professor Arthur H. Compton, of the University of Chicago, spoke on "Science as a Stimulus to Civilization." Dr. Compton also addressed the Physical Science Club in the afternoon on "Some Aspects of X-ray Scattering."

A SERIES of lectures on the circulation was delivered at the College of Medicine, University of Illinois, by Dr. Walter J. Meek, professor of physiology at the University of Wisconsin, from April 29 to May 1, the titles being, respectively, "Cardiac Output," "Automaticity and Conduction" and "Some X-ray Studies of the Heart."

THE 234th meeting of the Washington Academy of Sciences was held on May 15, when Professor Maynard M. Metcalf, of the Johns Hopkins University,

delivered an address on "The Origin and Evolution of the Higher One-celled Animals." This is the sixth of a number of lectures proposed by the academy on various phases of genesis and development or origin and evolution.

DR. BERNARD HAGUE, principal lecturer in electrical engineering at the University of Glasgow, delivered a lecture on April 26 before the Royal Canadian Institute on "The Contribution of Scientific Research to Some Recent Developments in Electrical Engineering." In September, 1929, Dr. Hague was granted a year's leave of absence to act as visiting professor in the Post Graduate School of the Polytechnic Institute of Brooklyn, New York, to conduct advanced courses in electrical theory and measurements.

THE Oliver-Sharpey Lectures before the Royal College of Physicians of London were delivered by Professor J. J. R. Macleod at the college on April 29 and May 1. The subject of the lectures was diabetes as a physiological problem.

THE Ingleby Lecture will be delivered at the University of Birmingham on May 22 by Sir John Bland-Sutton, past-president of the Royal College of Surgeons of England. The title of his lecture is "The Blood Trail."

A CHAPTER of Sigma Xi was recently installed at the Pennsylvania State College by Dean Ellery, national secretary, of Union College. There are 82 members of the society or associates on the faculty or connected with it. After the installation, Dean Ellery presented an address on "Radio Activity and the New Chemistry," which was illustrated with moving-picture films.

THE fifty-sixth chapter of the Society of the Sigma Xi was inaugurated at the University of Rochester on May 3. The program included a closed meeting, at which Dr. Edward Ellery, professor of chemistry and dean of the faculty at Union College, and national secretary of Sigma Xi, installed new officers. A dinner in his honor was given. Officers of the new chapter are: *Honorary President,* Dr. Herman LeRoy Fairchild, professor emeritus of geology; *President,* Dr. Victor J. Chambers, Charles Frederick Houghton professor of chemistry; *Vice-President,* Dr. George W. Corner, professor at the School of Medicine and Dentistry; *Secretary-Treasurer,* Quantin D. Singewald, assistant professor of geology; *Executive Committee,* Dr. T. Russell Wilkins, professor of physics; Dr. Walter R. Bloor, associate dean of the School of Medicine and Dentistry, and Hazel M. Stanton, psychologist at the Eastman School of Music.

THE gift of $1,500,000 by Cyrus H. K. Curtis to the projected Benjamin Franklin memorial and Franklin Institute Museum was announced on May 6 at a luncheon of the Poor Richard Club. Of the amount $500,000 will go to the $5,000,000 fund for the building and $1,000,000 will go to the endowment fund to sustain the museum. Mr. William L. McLean, publisher of the *Evening Bulletin,* Philadelphia, has given $100,000 to be used for erection of a heroic statue of Benjamin Franklin on the Parkway in connection with the proposed Benjamin Franklin Memorial and Franklin Institute Museum.

AS a memorial to the late Charles P. Taft, Mrs. Taft has given $2,000,000 to the University of Cincinnati.

DR. T. WAYLAND VAUGHAN, director of the Scripps Institution of Oceanography of the University of California, has given his personal scientific library for addition to that of the institution. This library includes approximately 800 bound volumes and 400 unbound volumes, together with 5,400 reprints. The books number about one ninth the present number in the library; the reprints about one third. Dr. Vaughan already had given the institution library about 150 bound volumes and 500 reprints.

A GRANT of $10,000 a year for two years has been made by the Rockefeller Foundation to the British National Institute of Industrial Psychology. This is the third grant which the Rockefeller trustees have made to the institute. The first grant, of $50,000, was made in 1926 for a period of five years. Most of this has been spent on research, and several reports will be published this year. The second grant was for $22,500, and was given to enable the institute to move into its present premises at Aldwych House.

DR. GEORGE E. JOHNSON, secretary, writes that the sixty-second annual meeting of the Kansas Academy of Science was held at the Kansas State Teachers College at Hays, Kansas, April 18 and 19, 1930. Two half days were devoted to general papers and business and one half day to section meetings. Dr. Wm. B. Wilson, of Ottawa University, delivered the presidential address on "The Kansas Academy of Science, its Position and Mission." Dr. T. D. A. Cockerell, of the University of Colorado, addressed the academy in the evening on April 18. His subject was "A Naturalist around the World." An arrangement was entered into with the University of Kansas, the Agricultural College and the Teachers College at Hays, whereby these institutions would contribute annually for ten years towards the publication of the *Transactions.* This also involved giving these institutions copies of the *Transactions* for purposes of exchange. The library of the academy is to be permanently deposited at the three institutions and the exchange list of the academy will be divided among them. The fol-

lowing officers were elected for the ensuing year: *President,* Hazel E. Branch, University of Wichita; *First Vice-president,* Roger C. Smith, Kansas State Agricultural College; *Second Vice-president,* Wm. H. Matthews, Kansas State Teachers College at Pittsburg; *Treasurer,* Ray Q. Brewster, University of Kansas; *Secretary,* George E. Johnson, Kansas State Agricultural College; additional council members, Wm. B. Wilson, Robert Taft, F. U. G. Agrelius and A. W. Barton. The section chairmen are as follows: *Chemistry-Physics,* Robert Taft; *Biology,* Mary T. Harman; *Psychology,* J. C. Peterson, president of the Kansas Psychological Association; *Entomology,* George A. Dean, president of the Kansas Entomological Society. The academy will meet at the university at Lawrence in April, 1930.

A SPECIAL health commission has been appointed by Governor Roosevelt to study the working of the public-health law of New York State and the various state and local authorities dealing with the promotion of health, as well as recent progress in public health in other states and abroad. The announcement of the creation of the commission stated that while New York has "one of the best public health laws of any of the states," and has a state health department which has wide recognition as a leader in its field, the great discoveries in medical science make it desirable every few years to have an appraisal to determine the possibility of a more effective application in actual practice of the latest results of scientific research in the means of preventing disease and conserving health. The governor stated that Dr. Livingston Farrand, president of Cornell University, has been asked to serve as chairman of the commission. Others invited to become members are Dr. George W. Cottis, Jamestown; Dr. Simon Flexner, Homer Folks, Dr. Edward L. Keyes, John A. Kingsbury, Mrs. Henry Goddard Leach, Henry Morgenthau, Gerard Swope, Miss Katherine Tucker and Dr. Linsly R. Williams, all of New York City; Dr. Matthias Nicoll, Jr., White Plains; John M. O'Hanlon, Troy; Dr. Thomas Parran, Jr., state commissioner of health, Albany, and Dr. William H. Ross, Brentwood.

DISCUSSION

THE NATIONAL FOREST RESERVATION COMMISSION AND FOREST RESEARCH RESERVES

READERS of SCIENCE for May 24 and June 28, 1929, will recall that the U. S. Forest Service has announced a policy of setting aside portions of the national forests, representative of virgin or relatively undisturbed conditions in each important forest type, as "research reserves" for scientific study; and that the National Forest Reservation Commission last spring approved the purchase, for its scientific value, of one hundred acres of original growth, known as Heart's Content, as a part of the Allegheny National Forest in Pennsylvania.

The report of the National Forest Reservation Commission to the Senate for the year ending June 30, 1929, will encourage the belief that the Forest Service is now in a much improved situation to carry out its announced policy with respect to research reserves. Owing to the extremely low price at which the bulk of the lands have been purchased for national forests in the East, very little virgin forest is now in federal ownership. Here and there, however, there are within the boundaries set for federal purchases privately owned tracts of original forest growth which, provided the National Forest Reservation Commission is willing to pay the prices asked for heavy commercial stands, may be added to the national forests. The commission's recent report, from the pen of its president *pro tempore,* Ray Lyman Wilbur, Secretary of the Interior, indicates a new attitude toward such purchases. It includes among the objectives of the acquisition program "promotion of reforestation and timber production on forest lands—by creating means for development of the principles and practices of silvicultural management necessary for successful timber-growing." What this phrase means may be inferred from the inclusion among the "outstanding features of the work of the National Forest Reservation Commission for the year" of "recognition of the desirability of the preservation of unmodified or virgin forest areas as nature laboratories for the promotion of silviculture." Further on in the report is the following reference to the purchase of the Heart's Content area:

> Notwithstanding the high commercial value of the heavy stand of white-pine timber, it is deemed eminently desirable that the government should acquire this property, not as a museum site or as a recreational tract but as a laboratory for the promotion of silviculture within which to study both the physical and biological aspects of the changes which take place in such forests, the concomitant changes in the white pine-hemlock forest type and the manner in which knowledge of these changes may be of value in guiding the development and management of the several hundred thousand acres of cut-over white-pine lands eventually to be acquired as the larger part of the Allegheny National Forest.

These principles, applied to future purchase programs, ought to result in the acquisition of other tracts suitable for research reserves. Their area can

not, of course, be large, but their value viewed from the scientific point of view will be all out of proportion to their size.

R. D. FORBES

ALLEGHENY FOREST EXPERIMENT STATION

SAND-STORM ELECTRICITY

THE discussions on atmospheric electricity in SCIENCE[1] called to mind an electrical display which accompanied a sand-storm which I witnessed in 1902.

I was on the White Mountain Apache reservation, in Arizona, on the day in question, when an ordinary desert whirlwind whirled into view from just around a southerly projecting point of land north of White River from the now abandoned Fort Apache. I had just crossed a flat area among the hills where an ancient lava flow once spread out, forming a "lava lake," an area probably six miles across from the afore-mentioned point to the mountainous hills to the northwestward, up which I was then ascending. In a moment it began to gain momentum on entering the level country and in a minute more it was a roaring funnel that was hurling immense quantities of dirt and sand skyward so that they formed an umbrella-like cloud around the apex of the whirling center.

As the twister was coming directly in my direction, I shifted southward over a gulch to another ridge to escape its fury. On it came. It entered the canyon in which I had been only a minute before. Here as the canyon both wedged-in and ascended toward the mountains in the direction it was going, the rushing whirl became "angry," as it were. The day had been perfectly clear. Yet in a moment there were chain lightning and ripping thunder on every side, while at the same time the whirler uprooted trees and tore large-sized boulders from their places on the canyon walls, finally destroying itself in that canyon.

From my observations I am inclined to believe that the electrical display that accompanied this whirl was due to the friction caused by the whirling débris.

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"SOUR SAP" IN TREES OF THE GENUS PRUNUS

ANNUALLY there occurs in stone fruits in the deciduous-fruit-growing sections of California a considerable loss of trees from a disease which is locally known as "sour sap." In certain seasons sporadic epidemics of this trouble occur when thousands of trees, usually from about three to ten or twelve years of age, die suddenly in an unaccountable manner and with no previous warning. The disease is primarily one of winter or early spring. Trees which appeared to be in perfect condition at the end of the season either fail entirely to start the following spring, lose one or more of the main limbs or linger along into the summer only to die before the end of the season. Various climatic combinations have in the past been held responsible for sour sap, although it has never been definitely known at just what time of the winter the initial injury actually develops. The name refers to a condition of the bark or cortex region of affected trees which is attended by decided souring and death of this portion of the host. The disease has been known for many years, and although many attempts have been made to discover the cause or causes of this mysterious trouble, only of late has its true nature been understood.

We have found that there are two distinct souring diseases of trees of the genus Prunus, one caused by bacteria and one due to the presence of stagnant soil water which affects the roots during the early growing period of the host.

The disease caused by bacteria is the more common of the two and is entirely distinct from the other. The bacterial organisms usually attack the host through wounds, such as pruning or grafting cuts, during the winter months and cause a progressive disease of the cortical bark region, usually in the trunk above the bud union or in the main crotches but sometimes killing only certain limbs or one side of the tree. The roots are rarely affected, in fact, an infection in the trunk usually stops its extension abruptly at the surface of the ground and the tree then sends up a mass of suckers from the root. The parenchymatous tissues, including the cambium, are invaded, producing a highly discolored, plasmolyzed appearance with a water-soaked, very sour advance, in which bacteria can be seen in the cells and in the intercellular spaces. The bacteria are usually present in zoogloeal masses but at times are quite free and motile. Extensive epidemics of this disease occur only in occasional seasons at irregular intervals, and it seems certain that some correlation must exist between certain seasonal climatic or soil moisture conditions and the development of sour sap. While many theories have existed in regard to this correlation we have really no definite information at all as to the nature of these conditions or even as to the specific time when they occur.

Our work covers a period of seven years of field observations and three years of inoculation experiments on a wide range of Prunus species and varieties, including peach, cherry, wild and cultivated plums, apricot and almond, with the result that the

[1] March 30, 1928; May 3, 1929; October 18, 1929, and January 24, 1930.

typical condition has been reproduced in all the above hosts. No one bacterial species is constantly associated with the trouble, and up to the present time we have isolated six types, each of which has caused extensive lesions in susceptible hosts when inoculated from pure cultures. Only during the months of December, January and February has this condition been induced experimentally; before and after this period small lesions develop but rarely damage the trees to any extent.

The souring of trees caused by stagnant soil water is prominent at times during the spring when the trees are starting into leaf. Trees standing in water which is moving through the soil are not damaged, but those subjected to stagnant water suffer in proportion to the damage to the roots. The leaves turn yellow, wilt as though lacking moisture, become brown at the edges and finally die. The affected roots become highly discolored and sour and die, while those not injured remain normal and continue to support the corresponding upper portion of the trees. In these cases a portion of the affected tree remains alive and continues growth. There are all gradations of top effect, and many cases recover if the water is drained off.

Many trees affected with sour sap of either of the above types become also infected with bacterial gummosis, which further complicates the question of the primary etiology of the trouble.

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SILVER OR GOLD

As a rule silver tarnishes to a greasy black color. I have found silver articles in the Near East which fail to blacken on weathering, but instead, become coated with a film of golden hue. One would think that the silver had been gold-plated. I investigated this interesting fact and discovered that silver originating in Caucasian deposits was particularly capable of this type of tarnishing. Apparently the small platinum content or the presence of some of the similar rare metals is responsible for this phenomenon.

Antique dress jackets of the Near Easterners, made of beautiful purple velvet and decorated with what seems to be gold braid, are to be found in the bazaars. This gold braid is silver—there is no trace of gold in it. Silver braid was used and in the course of time it tarnished to the gold color. Slightly rubbing it with a jeweler's touchstone reveals the silver beneath the outer film.

Two pieces of old Russian silverware, formerly used by the late czar of Russia, were presented to me. These were highly polished when given me. They are now beginning to exhibit this characteristic tarnish.

Some silver "Alexander the Great" coins which I unearthed in Macedonia fail to show this tarnish. The origin of the silver of these coins is probably Macedonia. Although silver is not found in Macedonia now, we do know that the early Greeks did find it along the banks of the Exidoros.

Perhaps all that glittered on the royal purple robes was not gold but silver!

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REPORTS

THE AMERICAN MUSEUM OF NATURAL HISTORY

DEFINITE plans to seek, through gifts from the public, $10,000,000 added endowment for the scientific and educational work of the American Museum of Natural History were adopted on May 5 by the trustees at their sixty-first annual spring meeting. The board confirmed selection of a committee, with President Henry Fairfield Osborn as chairman, to present actively during the balance of the year in the metropolitan area and throughout the country the needs of the institution.

This action followed submission of the annual report of the museum by President Osborn, who emphasized that mounting costs since the war and increasing demands for expansion of the museum's functions had brought about a severe financial stringency. Many important activities, he stated, were at a standstill or below normal, while projects necessary to keep the museum in its position of leadership in science and public usefulness were in abeyance.

"We are held back internally, while outwardly we are prospering," said President Osborn. "Annual public support of the museum, though increased, continues to fall far short of even the routine needs. Only the heavy emergency contributions by trustees have prevented the discharge of a large number of employees, but the budget thus temporarily balanced covers little more than ordinary maintenance for 1930. It holds no guarantee for succeeding years, and it has not prevented a sharp curtailment of the scientific work which is the very being of the museum and the basis not only of its prestige but of its unique service to the city, the state, the nation and the world at large.

"If the museum, which has become the particular pride of the people of metropolitan New York and virtually a household word all over the globe, is to continue its brilliant record of achievement, thus far

unbroken since its founding in 1869, it should have no less than $500,000 more in annual income. This would be accomplished by the sixtieth anniversary endowment fund of $10,000,000, first proposed some time ago, but thus far not vigorously advanced. So alarmingly urgent has become our situation that we can delay no longer. It is to be hoped that the next annual report will see this fund substantially in hand or promised."

Serving with President Osborn as a preliminary committee will be the following trustees: Treasurer James H. Perkins, Secretary S. Brinckerhoff Thorne, George T. Bowdoin, Douglas Burden, Cleveland E. Dodge, Clarence L. Hay, Junius S. Morgan, Jr., A. Perry Osborn, Daniel E. Pomeroy, Henry W. Sage, Leonard C. Sanford and Felix M. Warburg. George H. Sherwood, director of the museum, will be secretary of the committee.

Reviewing in his annual report the museum's status, which he declared was now threatened by lack of funds, President Osborn said: "All wealth and all health comes from knowledge of nature, and the American Museum of Natural History is advancing the knowledge of nature and the inspiration of nature on a scale unknown before in the whole history of education and of civilization."

But the present budget, he stated, was only "a minimum working budget," which had recently failed to cover some of the most valuable of the museum's activities. "Our explorations," he continued, "our researches, our expeditions, our publications, our educational work in school, college and university, our library, are suffering for want of adequate financial support to overcome the doubling or trebling of all costs since the fatal year 1914.

"The department of public health is entirely suspended; the library is very seriously crippled; were it not for Mr. Childs Frick's gifts, the department of vertebrate paleontology would have to stop its expeditionary work; other departments, like geology and geography and invertebrate paleontology, are operating at half their former rate; although under very able leadership, entomology is short-handed, and in practically all the exhibition halls of the museum the work of completing educational equipment has stopped.

"The two departments in which late President Morris K. Jesup was deeply interested, namely, woods and forestry and anthropology in all its branches, are restricted severely by retrenchment and undermanned."

Reporting on educational and scientific work of the museum, Director Sherwood noted the loss by death or resignation of seven members of the scientific staff, and added: "These men were all experts in their respective fields. It has been impossible to replace them because of the present critical financial emergency of the museum. In the depletion of our scientific personnel, research and publication are seriously retarded, and the museum is losing prestige in science.

"Overhead expenses must go on. They have had to be met at the expense of exploration, research and publication. The necessary financial retrenchment has reduced to a minimum the allowance for the research and publication side of the museum, until in 1929 almost none of the normal income could be devoted to exploration, which consequently has had to depend upon the special gifts of friends. When this situation is considered in conjunction with the museum's severe losses in scientific personnel the disastrous effect upon our scientific progress must be evident."

The income of the sixtieth anniversary endowment fund, it was announced by President Osborn, would be allotted for permanent support of exploration, research and publication; for additional assistants, to release curators and research workers for scientific projects and publication; for raising staff salaries to university and college grades; for the educational equipment and modernizing of the fifty old and new exhibition halls completed or under construction; for intensive high school, college and university education in laboratories and exhibition halls; for extension of the educational service, now reaching more than 1,000,000 public school children, to secondary schools; for preparation of existing exhibitions and collections to render the highest educational service to students and the visiting public, and for purchase of books to aid in the research activities. Provision also must be made, it was stated, for the development of future plans in connection with the addition of a new building section by the state and three new sections by the city, under the arrangement whereby the city provides land and buildings, and trustees and public the scientific work and the exhibitions.

G. N. P.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

HIGH FREQUENCY EQUIPMENT FOR BIOLOGICAL EXPERIMENTATION

GROWING interest in the biological utilization of the electromagnetic spectrum in the range of frequencies made available by improvements in the three electrode vacuum tube has led to the design of a convenient apparatus for treatment of the usual laboratory animals and materials.

With the apparatus here described high frequency fields can be applied to a wide variety of forms—from the smallest of insects to large rats. It has been found that very small objects require a concentration of the field and this requirement has been met by an arrangement for quick and easy interchange of plates in the exposure circuit, the subsequent tuning being accomplished merely by shifting an ammeter shunt along two parallel bars.

Frequencies from about 150.000.000 cycles per second (2 meters) to about 50.000.000 cycles per second (6 meters) are available. The circuit generating these frequencies is similar to those used by Schereschewsky[1] and Christie,[2] and the range is sufficient to cover that part of the spectrum found by Schereschewsky to be the most promising. The output on the exposure circuit can be conveniently controlled from 0 to about 4.5 amperes, the maximum being high enough to kill insects in a few seconds and mice or other small laboratory animals in from three to ten minutes.

The generating and exposure circuits are mounted on a wooden base built in the form of a stair step, the generating circuit being above and back of the exposure circuit. The overall length is thirty-nine inches, the height ten inches and the width fifteen inches. A slanting panel connects the two levels of the step, and the transformers, rheostat, fuses, etc., are placed behind this panel (Fig. 1).

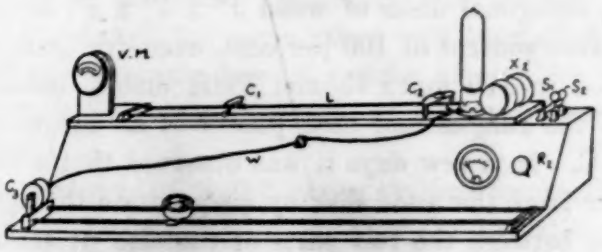

FIG. 1

In the accompanying diagram of this high frequency generator the generating circuit is shown at A and the exposure circuit at B (Fig. 2). The supply voltage for the filament and the plate of the vacuum tube is obtained from 110 volt, A. C., source. Five ampere fuses are used on the A. C. leads.

The transformer T_1 supplies current for heating the tube filament. An Acme 100 watt, filament lighting transformer is used. The primary voltage is 110 volts at 60 cycles and the secondary voltage is 12. Transformer T_2 supplies the plate voltage; it is rated at 100 watts, 110 volts primary, 1100 volts secondary. Two small 15 ampere S. P. S. T. knife switches are provided, S_2 controlling the filament current and S_1 the plate voltage.

At X_1 is a small high frequency choke in series with the plate transformer winding and with the oscillator inductance rod L. It is composed of about fifty turns of No. 36 D. S. C. magnet wire wound on a ¼-inch tube of insulating material. It may be omitted if the transformer is located at some distance from the oscillator. At R_1 is a grid leak resistor. It is not critical and may be of from 5.000 to 10.000 ohms.

The by-pass condenser C_1 must be of such insulation as to stand the plate voltage. A Sangamo 250 micro-microfarad condenser sealed in bakelite is satisfactory. A tuning condenser is placed at C_2. It is a small two-plate variable condenser and was made by removing all but one stationary and one rotary plate from a General Radio 15 micro-microfarad variable condenser. At X_2 are two high frequency chokes made by winding about fifteen turns of No. 14 copper wire on a 2½-inch diameter tube.

The rheostat at R_2 is for the control of the filament current. Almost any type of .5 ohm rating will do. It should be of such resistance and current capacity as to limit the filament current to about 6.25 amperes when used in conjunction with the filament transformer above described. The ammeter A on the generating circuit provides a check on the filament current. A Jewell, pattern No. 74, 0–8 amperes, A. C., is satisfactory.

The inductance rods L, upon which C_1 slides, are ¼-inch copper tubes about 22 inches long. They may be of any length depending upon the highest wavelength desired. The separation of the two rods at L alters their inductance materially as well as their high frequency resistance, and, for this reason, a separation of less than two inches is not recommended. In this instance the separation is 2.25 inches.

By changing the position of the by-pass condenser C_1 along these rods a means is provided for changing the inductance in the oscillatory circuit, and hence the frequency. As a means of fine adjustment to a predetermined frequency, the small variable condenser C_2 is connected at the base of the tube. The actual frequencies generated may be conveniently measured by the Leecher wire system.

The exposure circuit is similar to the oscillatory circuit except that here the vacuum tube capacity has been replaced by the condenser plates C_3. It is between these plates that the actual exposure of experimental material is made. Both the oscillatory and

[1] J. W. Schereschewsky, Public Health Service Bulletin, 1926, p. 1939; Public Health Service Bulletin, 1928, p. 927.

[2] R. V. Christie and A. L. Loomis, *Journal of Experimental Medicine*, 49, v. 2, 1929.

exposure circuits are shown in the diagram (Fig. 2) by heavy lines.

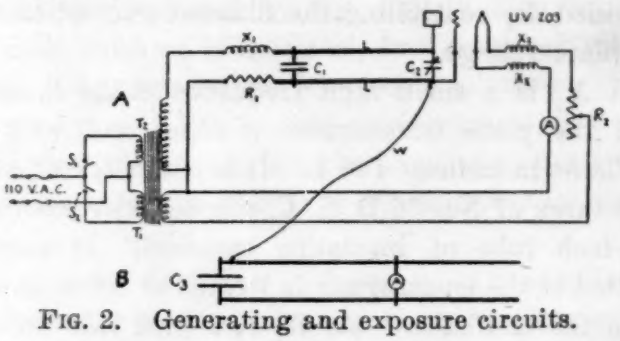

FIG. 2. Generating and exposure circuits.

On the exposure circuit there are also two parallel rods of ¼-inch copper tubing, in this case at 3½ inches separation; and, in order to give sufficient tuning range, they are 34 inches long. Along these rods, acting as a shunt, slides the ammeter A of the exposure circuit. This ammeter provides a means of determining the point of resonance of the circuit, and also a relative measure of the output. A Jewell, pattern No. 64, Radio Frequency, 0–5 amperes, is used. The actual tuning of the exposure circuit may be accomplished either by changing the position of the ammeter along the two parallel rods or by changing the separation of the condenser plate C_3.

Two metal posts about four inches high hold the condenser plates at C_3. These posts are connected at their bases with the two parallel rods; they may be insulated by a cross member of bakelite or some other insulating material. Although not absolutely necessary, the whole of the exposure circuit may be insulated from its wooden support. The plate posts are drilled and threaded for a ¼-inch bolt. Circular sheet copper plates of varying size may be screwed to these bolts by soldering the proper-sized nut to the back of each plate.

Coupling between the oscillatory and the exposure circuits presents somewhat of a problem when dealing with frequencies as high as here used. It has been found best to use a very loose inductive coupling and then provide a single wire feeder much like the usual radio antenna feeder. This wire feeder is shown at W on the circuit diagram. The coupling may be varied by changing the position of the feeder clip on the grid inductance rod of the oscillator. However, in practice it has been found that little change in coupling is required.

Several types of standard vacuum tubes could be adapted to this apparatus, but the UV 203, 50 watt tube has proved very satisfactory. It has a high filament emission as compared to tubes with thoriated filaments, and it gives sufficient output for nearly all kinds of biological experimentation. With this tube the lowest wave-length available is about three meters, although it is possible by tuning to the second harmonic on the exposure circuit to use a wave-length of less than two meters. Higher wave-lengths are easily obtained by extending the length of the rods in the oscillatory circuit. For lower wave-lengths a push pull oscillator composed of tubes of very low internal capacity is necessary. Amplifiers to increase the output of vacuum tube oscillators at these wave-lengths have not proved satisfactory.

To the apparatus here described may be added an A. C. voltmeter at the 110 volt A. C. source. If it is desired, larger animals than rats may be treated by adding a set of square exposure plates of large size and wide separation. These plates may be mounted on the slanting panel and connected by copper rod feeders to the exposure circuit.

All the parts listed are standard electrical equipment and may be obtained from radio supply houses at remarkably low cost.

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REDUCING MOISTURE EVAPORATION FROM PETRI DISH CULTURES

GROWTH-RATE studies and other laboratory studies of wood-rotting fungi require a constant moisture content of the wood upon which such tests are made. This is essential to the control of the moisture factor, which is an extremely important one in all such studies. In one of the growth-rate studies now under way, octagonal disks of wood 3″ x 3″ x ⅛″, having a moisture content of 100 per cent. oven-dry basis, were placed in 100 mm x 15 mm Petri dishes, inoculated with the fungus and then placed in an incubator at 27° C. In a few days it was observed that a loss of water from the wood disk by evaporation through the space between the two parts of the dish proceeded at such a rapid rate that growth of the mycelium was inhibited, and if continued for a longer period death of the fungus resulted.

To prevent this loss of water, it was suggested that the space between the cover and the bottom of the dish be filled with a plastic, impervious substance, such as modeling clay, paraffin or beeswax. However, the inconvenience of sterilizing, then introducing these materials into the crevice, presented difficulties that were reduced by the use of another method. This method is simple but effective and consists in the application of a wide rubber band to the periphery of the dish so that it covers the opening between the two parts and overlaps on the bottom and top sufficiently to prevent slipping off (Fig. 1). The bands were especially made by A. W. Faber in two sizes, 3⅜″ long by 2″ wide, for use with Petri dishes of 15 mm depth, and 3⅜″ x 1¾″ for those of less depth.

The rubber is of the same weight as that used in Faber's large, office band, $3\frac{3}{8}'' \times \frac{3}{4}''$. These sizes fit snugly, with no loose edges, and leave the top of the dish unobstructed for observation and measurements.

FIG. 1. Drawing showing the wide rubber band A, surrounding the edge of the Petri dish, in which is enclosed the flat, octagonal piece of moist wood, B. The fungous inoculum is shown at C, and the mycelium which spreads from it is indicated at D. The number, 107, indicates the number of the test piece.

The band method greatly reduces water loss, though it does not completely prevent it. The average loss per week when using bands was shown to be from 0.2 to 0.4 of a gram per dish containing wood test pieces at 100 per cent. moisture content, whereas without any protection this loss is from 2.0 to 3.8 grams. The difference is so marked that further explanation is unnecessary.

This method is applicable to toxicity tests of wood preservatives, studies in the decay resistance of woods, the determination of moisture and temperature requirements of fungi, cultural tests of various kinds and to a variety of uses where controlled moisture conditions are desired for test materials or living organisms contained in Petri dishes.

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SPECIAL ARTICLES

THE DISPLACEMENT OF TOXIN FROM NEUTRALIZED TOXIN-ANTITOXIN MIXTURES BY "TOXOID" OR ANATOXIN

MADSEN and S. Schmidt[1] have recently shown that neutralized toxin-antitoxin mixtures become toxic on addition of anatoxin. Schmidt[2] also showed that "toxoid" exerted the same effect and concluded that toxoid and anatoxin have a greater affinity for antitoxin than the original toxin itself, and can therefore displace it.

The tendency of recent immunological work (Obermayer and Pick, Landsteiner, Avery and Goebel) has been to show that even minute alterations in the structure of an antigen diminish an existing specificity rather than augment it, so that it would seem preferable to seek some other explanation.

This can readily be found in the conception of Arrhenius and Madsen[3] that the toxin-antitoxin reaction is a reversible chemical equilibrium of the type $T + A \rightleftarrows TA$, to use the simplest possible form, in which T = toxin and A = antitoxin. Letting this equation represent a "neutralized" mixture, we may express the equilibrium state by $\frac{[T][A]}{[TA]} = K$, or $[T][A] = K\,[TA]$, in which K is the equilibrium constant and the bracketed letters refer to concentrations. Since the toxin in the mixture is "neutralized," [T], and consequently K, are relatively small at equilibrium.

If the concentration of any of the reactants is changed the relative quantities of the other constituents also change so that K remains constant. Thus, if an additional amount of T is added it reacts with part of the A, decreasing [A] and increasing [TA], thus keeping K constant. If some other substance capable of reacting with A is added, [A] will also be decreased, but to keep K constant some of the TA will dissociate, increasing [T] and decreasing [TA].

Such a condition would arise when anatoxin or toxoid is added to a neutralized toxin-antitoxin mixture. If toxoid (Td) reacts with antitoxin in the same way that toxin does, $Td + A \rightleftarrows TdA$, a similar mass-law expression may be formulated, namely: $\frac{[Td][A]}{[TdA]} = K'$.

If toxoid is now added to a mixture containing neutralized toxin, the component substances will interact until their concentrations fulfil the conditions of the mass law equations $\frac{[Td][A]}{[TdA]} = K'$ and $\frac{[T][A]}{[TA]} = K$. As [A] is common to both expressions a relationship between [T] and [Td] can be derived, namely, $\frac{K[TA]}{[T]} = \frac{K'[TdA]}{[Td]}$. If the assumptions are made that one equivalent of TA is present before addition of one equivalent of Td, that the concentrations of

[1] T. Madsen and S. Schmidt, *Compt. rend. soc. biol.*, 102: 1091, 1929.
[2] S. Schmidt, *ibid.*, 1095.
[3] Arrhenius, "Immunochemistry," Chapters VI and VII, New York, 1907.

free T and A in a "neutralized" mixture are negligible and that x equivalents of TdA are formed at the expense of TA, the expression at equilibrium would be

$$\frac{K[1-x]}{[x]} = \frac{K'\ [x]}{[1-x]}.$$

This would, of course, be strictly true only if K is so small that essentially all of A is in the form of TA. If K = K′, that is, if T and Td have the same affinity for A, x = 0.5. In other words, one half of the toxoid added has combined with the antitoxin and half of the toxin has been liberated.

If K = 0.5 K′ (Td has 0.5 the affinity of T for A), x = 0.41;
if K = 0.1 K′, x = 0.24;
if K = 0.01 K′, x = 0.09.

Thus, in the case considered, even if T has one hundred times the affinity of Td for A, an appreciable amount of toxin would be liberated from the neutralized mixture by the addition of Td. Actually, the greater the value of K, the smaller the amount of toxin liberated, since free A would be greater and less dissociation of TA would occur. However, if one accepts the experimental results of Madsen and Schmidt, as well as the explanation herein given, K must be relatively small, since liberation of toxin is actually observed.

Interesting in this connection is the analogy to the toxin-toxoid reaction pointed out some years ago by Northrop;[4] namely, that a pepsin-albumin mixture diluted with inactivated pepsin contains more active pepsin than one diluted with buffer alone, the effect being in harmony with the hypothesis that inactivated pepsin, as well as active pepsin, combines with the peptone formed by digestion of the protein.

A simple physicochemical consideration of the conditions of equilibrium therefore suffices to account for the increase in toxicity of neutralized toxin-antitoxin mixtures to which toxoid or anatoxin has been added, and the experimentally untouched affinity relations of these as yet vaguely defined substances need not be taken into account.[5]

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A NEW LAW OF SATELLITE DISTANCES

BESIDES the celebrated Bode's (or Titius) law there have been a number of attempts to establish a law governing the distances of satellites from their central body, including two discussions of the subject in SCIENCE in 1929. My approach to this subject was made about four years ago in somewhat the same manner as that of Dr. A. E. Caswell[1] who holds "the mean distances of the planets from the sun are proportional to the squares of simple integral numbers." I added, however, to the square of the integer the integer itself, thus assuming that the terms differ from the squares of integers by a progressively changing amount. For example, adding to each of the integers 1, 2, 3, 4, 5 . . . its square, we obtain the values 2, 6, 12, 20, 30. . . . This is simplified by dividing throughout by 2, giving us the series 1, 3, 6, 10, 15. . . . Those familiar with Bernoulli's *Tabula Combinatoria*[2] will recognize the series as the ternaries of his table.

The following table shows the results for all the satellite systems, including the planets as satellites of the sun, of the solar system where there are at least

TABLE ILLUSTRATING LAWS OF SATELLITE DISTANCES

System	Satellite	Relative Distance	New Law	Bode's Law	Caswell's Law
Sun	Mercury	3.87	3	4	3.82
"	Venus	7.23	6	7	6.80
"	Earth	10.0	10	10	10.6
"	Mars	15.2	15	16	15.3
"	Ceres	27.7	28	28	27.2
"	Jupiter	52.0	55	52	51.4
"	Saturn	95.3	91	100	95.6
"	Uranus	191.0	190	196	187.0
"	Neptune	300.0	300	.....	310.0
"	"Planet X"	400.0	406	388	408.0
		430.0	435	388	435.0
Mars	Phobos	1.00	1	.....	1.70(1)
"	Deimos	3.22	3	4	3.82
Jupiter	V	2.71	3	4	3.82
"	I (Io)	6.27	6	7	6.80
"	II (Europa)	10.0	10	10	10.6
"	III (Ganymede)	15.8	15	16	15.3
"	IV (Callisto)	27.9	28	28	27.2
"	VI	169.4	171	.....	170.0
"	VII	173.0	171	196	170.0
"	VIII	348.5	351	.....	357.0
"	IX	371.0	378	388	382.0
Saturn	Mimas	10.0	10	10	10.6
"	Enceladus	12.8	.....	.....	.....
"	Tethys	15.8	15	16	15.3
"	Dione	20.3	21	.....	20.8
"	Rhea	28.0	28	28	27.2
"	Titan	66.0	66	52	61.2
"	Themis	78.1	78	.....	83.1
"	Hyperion	79.0	78	100	83.1
"	Iapetus	190.0	190	196	187.0
"	Phoebe	698.0	703	772	712.0
Uranus	Ariel	10.0	10	10	10.6
"	Umbriel	14.1	15	16	15.3
"	Titania	22.8	21	.....	20.8
"	Oberon	30.4	28	28	27.2

[1] A. E. Caswell, "A Relation between the Mean Distances of the Planets from the Sun," SCIENCE, n.s., 69: 384, 1929.

[2] D. E. Smith, "Source Book in Mathematics," p. 273, 1929.

[4] J. H. Northrop, *J. Gen. Physiol.*, 2: 482, 1919–20.

[5] The authors of this paper are working under the Harkness Research Fund of Presbyterian Hospital.

two known satellites on which to base comparisons. The base term for the relative distances in each satellite system is 10 except in the case of Mars where it is one. Distances under Bode's law (represented by the series 4, 7, 10, 16, 28, 52, 100, 196, 388 and 772) are included not only for comparison of the results with those of the new law but also because that law gives very good values for some of the planetary satellites as well as for those of the sun. Likewise the distances under Dr. Caswell's law are included. These are obtained as explained in his article in SCIENCE.[1]

The new "Planet X" has been officially reported in a circular from the Lowell Observatory as having a distance from the sun of 40 to 43 astronomical units. Therefore double values have been included in the table until a more accurate determination of the distance is made. Enceladus, the second satellite of Saturn, does not, apparently, belong to any of the three series, but it is here included for completeness. The orbit of Themis is not accurately determined, but it seems that there may be a faint satellite at about the distance given. If in the satellite system of Mars 10 be taken as the relative distance for Deimos, better values will be obtained for the Bode and Caswell series, but the value of one was adopted for Phobos instead because of the near correspondence of the distance of that satellite to that set by Roche's limit. Ceres, the largest of the asteroids, is included in the table although it may belong to a system of harmonics rather than to the fundamental series. Referring to the table, it is seen, of course, that not all of the successive terms of the new law are represented in any one satellite system nor are the same terms represented in different systems.

It is important to notice that Bode's law gives fairly good values for at least five of Jupiter's satellites, for four of those of Saturn and for three of those of Uranus. This fact seems to be overlooked in nearly all modern popular discussions although it was referred to in some articles fifty years ago. Sir James Jeans,[3] like many others, has said ". . . it seems more than likely that it [Bode's law] is a mere coincidence with no underlying rational explanation." Yet Bode's law is an approximation for several terms both of Dr. Caswell's law and of my own, and Dr. Caswell[1] believes that his series "suggests the possibility that the orbits of the planets may be 'quantized' somewhat after the manner of the electronic orbits in the Bohr atom." The quantum principle is important in wave-theory, and my own solution resulted from studies in that field. The new series can be derived by taking the fiction, employed in the mathematics of a vibrating sphere, of a double source of wave-action of suitable strength at the center of the sphere and by modifying this concept to that of two sources of wave-action whose distance apart is relatively small in comparison with the length of the waves set up in the surrounding medium. Then, by disregarding the distance apart of the two sources, it is possible to develop the series by superposition. This assumes that the solar system can be treated somewhat on the order of the Schrödinger[4] atom rather than that of Bohr. A French writer, Lieutenant-Colonel Delaunay,[5] also believes wave-action is important in this problem. Finally, Victor Goldschmidt, of Heidelberg, according to Dr. Malisoff,[6] has shown that "a mathematical treatment strictly analogous to the phenomena of *standing waves in sound,* the distribution of lines in spectra, the progress of crystallization and similar phenomena gives the same law of harmonic relations of distances not only for the planets but also for satellites." Referring to Goldschmidt's[7] original article, I find that he has represented the distances of the planets as follows: Mercury 3.90; Venus 7.10; Earth 10.0; Mars 16.7; Jupiter 50.0; Saturn 100; Uranus 200; Neptune 300, and (following his method) "Planet X" 400. Dr. Caswell[1] has given it as his opinion that "on the whole the agreement is good, and can scarcely be accidental." After considering all this evidence independently arrived at by different investigators I am disposed to agree with him and offer as my opinion that Bode's law, as a first approximation, may have its origin in actual causal phenomena.

J. B. PENNISTON

SEATTLE, WASHINGTON

[3] Sir James Jeans, "The Universe around Us," p. 20, 1929.

[4] Arthur Haas, "Materiewellen und Quantummechanik" (p. 81 in Eng. trans. by L. W. Cobb, "Wave Mechanics and the New Quantum Theory," London, 1928).

[5] Lieutenant-Colonel Delaunay, "Problèmes Astronomiques," Paris, 1920.

[6] William Marias Malisoff, "Some New Laws for the Solar System," SCIENCE, n.s., 70: 328–329, 1929.

[7] Victor Goldschmidt, "Über Harmonie in Weltraum, ein Beitrag zur Kosmogonie," *Annalen der Naturphilosophie,* 5: 51–118, Leipzig, 1906.

THE NATIONAL ACADEMY OF SCIENCES

AT the annual meeting of the National Academy of Sciences, held in Washington on April 28, 29 and 30, the following papers were presented:

The structural basis of the integration of behavior: G. E. COGHILL (introduced by C. Judson Herrick). The development of behavior in a lower vertebrate, in which

movements can be observed from the first muscular contraction to the adult condition, is a process of expansion of a pattern which is from the first always integrated. Within this integrated total pattern partial patterns such as reflexes emerge with varying degrees of individuality of their own. This is accomplished by a progressive restriction of the field of adequate stimulation of the partial patterns as well as of the patterns themselves. This law is also exemplified in the structural development of the nervous system, and apparently holds for higher vertebrates and man. It is the unifying principle which brings order out of the chaos which has hitherto prevailed as regards various categories of behavior, such as simple reflexes, chain reflexes, conditioned reflexes, instincts, habits, trial and error.

Localization of function in the nervous system: C. JUDSON HERRICK. Analytic functions, such as specific reflexes, are performed by precisely localized organs. Synthetic or integrative functions seem to pertain to the organism as a whole. But these too have organs; they are not disembodied; and our problem is: What is this apparatus? Genetically, specific local reflexes arise within and are derived from mass-movements or total reactions (Coghill). Parallel with elaboration of these localized reflex arcs, special integrating apparatus is developed—the diffuse nervous felt-work, or neuropil. This is the parent tissue from which the mechanisms of all higher nervous functions are differentiated—correlation, association, learning, memory, intelligence. This apparatus of the personality as a whole has location in space, but the pattern of this localization is radically different from that of specific reflexes, and the pattern of performance is different.

Observations on asphyxia bearing upon the adjustment of respiration to diminished pressures of oxygen at great altitudes: YANDELL HENDERSON and ELLEN M. RADLOFF. Healthy men who ascend such mountains as the Himalayas, requiring several weeks, develop an acclimatization which permits them to be comfortable and even to make great physical exertions. If, on the other hand, the ascent to such altitudes is made in a few hours by balloon or railroad train, as in the Andes, intense mountain sickness, physical incapacity and even death may result. The study of the process of acclimatization has shown that the volume of breathing per unit of gaseous exchange in acclimatized men corresponds to the decreased pressure of oxygen. The primary increase of breathing might be due either to accumulation of lactic acid and other incomplete combustion products or to a primary effect of low oxygen inducing over-breathing and thus rendering the blood temporarily more alkaline than normally. The results of our investigation of the changes in the blood in dogs during asphyxia favor the latter conception.

Virus disease and the central nervous system: SIMON FLEXNER. By a virus disease is meant one induced by a micro-organism so small that it has not been rendered visible by the most powerful microscope. Such micro-organisms or viruses are, because of their minute size, capable of passing through the pores of earthenware filters, which hold back ordinary bacteria. This property has led to these viruses being called "filter passers" or "filterable viruses." Viruses produce disease in plants and in many, if not all, orders of animals. The particular interest which they have for us to-day depends upon the fact that they are not only responsible for severe diseases among mammals, including man, but that the diseases are often attended by symptoms indicating involvement of the central nervous system. Poliomyelitis, or infantile paralysis, is an excellent example of this condition; another is rabies, or hydrophobia. In smallpox, measles and certain other virus diseases of man it occasionally happens that the central nervous system is affected, in which case the gravity of the original disease is intensified. In domestic mammals virus diseases attended by nervous complications are found among horses (Borna's disease), rabbits, guinea-pigs, dogs (distemper), etc. In certain instances the virus diseases of the lower animals are communicable to man (*e.g.*, psittacosis, or parrot disease); on the other hand, virus diseases of man can be communicated to the lower animals (*e.g.*, poliomyelitis, typhus fever, yellow fever). We are just beginning to learn the frequency with which the central nervous system is involved in the virus diseases of man and of animals. It appears that the viruses themselves may be divided into two classes: (1) those which tend to attack the central nervous system predominantly, and (2) those which attack other organs with greater intensity and frequency than the central nervous system. The first class of viruses produces diseases which are in essence affections of the central nervous system; the second class, diseases in which affections of the nervous system are more in the nature of complications than of essential disease.

Biological studies of the tubercle bacillus—(1) *Instability of the organism—Microbic dissociation:* S. A. PETROFF (introduced by Hans Zinsser). It has been increasingly evident during recent years that bacteria along with the other living forms are subject to modification. From the accumulated evidence in the last fifty years it seems that the tubercle bacillus, which has been considered by many investigators as one of the most stable micro-organisms, is also subject to modification. No explanation has been offered as to the cause of the morphological, cultural and virulence variations. In this paper we shall discuss the instability and microbic dissociation of the tubercle bacillus, for the study of which new methods and media have been devised. (*a*) Three types of colonies have been dissociated from the avian tubercle bacilli. One is perfectly round, smooth and appears like moth-ball, is easily emulsified, grows best on alkaline media and is highly pathogenic for chickens. The second type is flat, moist, with smooth surface, and is emulsified with difficulty. The third type is flat and dry, the center giving the appearance of small pebbles. This colony is also difficult to emulsify. The second and third types are not so virulent for chickens as the first. (*b*) Three types of colonies have been isolated from a

bovine tubercle bacillus culture grown on special gentian-violet egg media. One is perfectly round, smooth, moist, appears as moth-ball, emulsifies easily and grows best on alkaline media. Morphologically it is composed of small intact rods, and granules are absent. The organism is highly pathogenic for guinea-pigs and rabbits. The second type is flat, with a moist smooth surface and raised center. It grows best on acid media. The rods are longer and beaded. It produces less extensive tuberculosis in laboratory animals. The third is flat, dry and the structure appears like small pebbles. It emulsifies with difficulty in salt solution and is only sometimes pathogenic for guinea-pigs and rabbits. (*c*) From the BGG cultures, we have dissociated two extreme types of colonies. One is large, flat, with large folds, appears very waxy, grows best on acid media and is not pathogenic for guinea-pigs or rabbits. The second is a large flat colony, the center appears like honey-comb and the periphery is veil-like. It grows best on alkaline media and is pathogenic for guinea-pigs and slightly for rabbits. (*d*) The human tubercle bacillus has not been completely dissociated. It seems that this organism presents large numbers of variant colonies, which are quite unstable. Some of these colonies have been successfully reverted, one into the other, by a special method of cultivation. It seems that the tubercle bacillus as compared with other organisms is also quite unstable. The studies indicate that the factor of instability must be taken into consideration when discussing any problem in tuberculosis.

The architecture of living cells. Optical sectioning with the ultra-violet microscope: FRANCIS F. LUCAS (by invitation). This paper describes a new tool for biological research. It is the ultra-violet microscope perfected and reduced to practice. With new technique it is possible to section optically living normal and malignant cells and to photograph them at very high magnifications and with a degree of resolution never heretofore achieved. The average living cell is about 1/3,000 inch in diameter. This living cell, itself invisible to the unaided eye, is "sliced" into sections spaced about 1/100,000 inch apart and photographs of each section are taken without materially interfering with the normal behavior of the cell. In the average cell thirty or even more photographs may be taken on uniformly spaced optical planes. At magnifications as high as 5,000 diameters the interior architecture of living cells is photographed. By virtue of the invisible monochromatic ultra-violet light which is used the resolving ability of the system is about twice that by other known means. The apparatus is briefly described and illustrated and photographs are included of the structure of normal and malignant living cells. Several photographs show the sectioning method applied to living brain cells.

The sense of hearing in fishes: KARL VON FRISCH (introduced by R. G. Harrison). Fishes (minnows, *Phoxinus laevis*) can be trained to react to sounds of whistles, tuning-forks, etc. They are fed from a glass rod and at the same time the training sound is given. The sense of sight is eliminated by blinding. After some days the fish gives a very typical reaction to sound. It snaps and seeks for the food at once when the sound is given, before the food is put into the water. The upper limit in minnows is between 4,000 and 7,000 v.d. The low limit could not be found. The lowest tuning-fork (16 v.d.) gives good results. The acuteness of the sense of hearing is about the same as in man under similar conditions, that is, when he is completely immersed in a large aquarium. Minnows can be trained to distinguish between different sounds, a feeding sound which means food, and a warning sound which means a punishment (a light blow with a glass rod). The best fish could distinguish perfectly the two sounds of a minor third (290 and 345 v.d.) in a long series of experiments. Fishes from which the utriculi, semicircular canals and ampullae have been removed have entirely lost the sense of equilibrium; nevertheless they can be trained to sounds as easily as normal fishes, in the same time, within the same limits, and the acuteness of the sense of hearing is the same as in normal fishes. The reactions of such fishes are especially impressive. When they are lying on the bottom of the aquarium and the whistle is blown, they rise very vigorously and swim through the aquarium turning somersaults again and again. Fishes with both lagenae and sacculi removed are fully in equilibrium; but it is impossible to train them to sounds higher than 130 v.d. To low sounds training is possible. The fish without sacculus and lagena can even distinguish between different sounds in the low region as well as normal ones. Therefore lagena or sacculus, or both, are the organs for the perception of middle high and high sounds. Whether the low sounds are perceived by means of the skin or the lateral line organ has not yet been definitely determined. All the reactions described here are shown in moving pictures during the lecture. These experiments, performed together with Dr. Stetter, are to be continued.

Action currents in the auditory nerve in response to acoustical stimulation; experiments demonstrating the correspondence between sound and nerve impulse: ERNEST GLEN WEVER and CHARLES W. BRAY (introduced by E. G. Conklin). By placing an electrode on the cat's auditory nerve near the medulla, with a grounded electrode elsewhere on the body, and leading the action currents through an amplifier to a telephone receiver, the writers have found that sound stimuli applied to the ear of the animal are reproduced in the receiver with great fidelity. Speech is easily understandable. Simple tones, as from tuning-forks, are received at frequencies which, so far as the observer can determine by ear, are identical with the original. Frequencies as high as 3,300 cycles per second are audible. Numerous checks have been used to guard against the possibility of artifact. No response was obtained when the active electrode was placed on any other tissue. After destruction by pithing of the cochlea on the electrode side, the intensity of the response was diminished; after destruction of the cochlea on the other side as well, the response ceased. The response ceased

when the circulation to the head was restricted by pressing the vertebral arteries, and returned when normal circulation was restored. Likewise, the response ceased when a steady direct current was applied to the nerve, and returned when the direct current was removed. This result, that the frequency of impulses in the auditory nerve varies according to the frequency of the stimulus, does not bear out the expectation based upon the recent experiments on other sensory nerves, where it has been found that frequency of impulse varies according to intensity of stimulus. Moreover, the correspondence shown between sound and nerve impulse requires an abandonment, or at least an essential revision, of the modern formulation of the Helmholtz theory of audition.

Accumulation of electrolytes in valonia: W. J. V. OSTERHOUT. Electrolytes often seem to contravene physical laws by diffusing against a gradient and reaching a greater concentration inside a living cell than outside. This seems to take place in the marine alga *Valonia macrophysa*, which forms large cells up to the size of a pigeon's egg. This may be accounted for (to a large extent at least) by the fact that the inside of the cell is more acid than the outside. A theory based on this has been successfully applied.

Compensating extrachromosomal types in Datura and their use as testers: A. F. BLAKESLEE, A. D. BERGNER and A. G. AVERY. A compensating chromosomal type is one in which parts from two different aberrant chromosomes compensate to form the equivalent in genic content of a whole normal chromosome. These two compensating chromosomes together, therefore, may replace a normal chromosome, and their non-compensating parts be left over as extra chromosomal material to cause morphological changes in the plant affected. Since in such compensating types each of the aberrant chromosomes contains parts from two different normal chromosomes, a chain of seven attached chromosomes is found at reduction. If a compensating type is crossed with pollen from a race derived by segmental interchange between any of the chromosomes involved in the two compensating chromosomes, then a chain of nine chromosomes results at reduction and all the normal sex cells of the hybrid will have the chromosomal constitution of the pollen parent. Thus, without cytological study, one can be certain of the chromosomal constitution of the offspring from such hybrids with compensating types. The use of such types has enabled us to demonstrate crossing over of genes between chromosomes in attached chains and to transfer genes from one chromosome to another without the necessity of chromosomal study. Methods for obtaining new compensating types have been developed. Thus in the offspring of a plant with a circle of six attached chromosomes, from one to three distinct compensating types should be expected, dependent upon the nature of the segmental interchange involved in the circle.

Incubation period of peach yellows as affected by point of inoculation: L. O. KUNKEL (introduced by R. A. Harper). Those who have studied the transmission of peach yellows by budding and grafting report a long and variable incubation period for the disease. Smith found that the first symptoms usually appear from one to two years after trees are inoculated. The writer's experiments show that under ordinary greenhouse conditions the incubation period of yellows can be reduced to a minimum of about six weeks if vigorous young seedlings are used and the trees are inoculated at some distance above the ground level. Transmission is certain, and the incubation period shown by different individual trees is quite uniform in length under these conditions. The importance of inoculating trees above the ground level depends on the fact that the virus of peach yellows moves quickly down but rather slowly up the peach stem. It has been found to move down more than ten times as fast as it moves up. If inoculations are made at or very near the ground level, as is the case when trees are budded according to the usual nursery practice, the incubation period often extends over many months. The tops of such trees remain healthy for a long time because of the slow upward movement of the virus. A knowledge of the importance of the point of inoculation in determining the length and uniformity of the incubation period of peach yellows will greatly reduce the time and work necessary for testing various species of insects that are suspected of spreading this disease.

The character and causes of the extreme fluctuations in the abundance of the American mackerel: OSCAR E. SETTE (introduced by G. H. Parker). The remarkable fluctuations in the American mackerel fishery have long awaited a scientific explanation. During the last century the annual catch has been as large as 120,000,000 and as low as 4,000,000 pounds. During recent years, the annual yield has been between 30,000,000 and 50,000,000 pounds. Older theories ascribe the great changes in catch to variation in the availability of the mackerel to fishermen, but recent investigations by the U. S. Bureau of Fisheries have shown that variations are due almost entirely to actual changes in the number of mackerel in the sea. The reason for the great difference in the abundance of mackerel is that some spawning seasons fail to produce many mackerel while others are much more successful. When many mackerel result from spawning, the stock is built up and the sea is full of mackerel for the following years. When, on the other hand, there comes a series of years during which no new mackerel are added to the schools, the stock of older mackerel dwindles as the result of fishing and natural deaths, so that a period of scarcity sets in when the fishery suffers lean years until another good brood is hatched and grows to market size. The relatively large catches of recent years were due to the remarkable numbers of mackerel which resulted from the spawning of 1923, for this brood has accounted for three quarters of the commercial catch in the last five years. Other broods were virtually negligible, though those of 1921 and 1927 have contributed a few mackerel and the 1928 brood shows promise of making more substantial additions to

the stock. Investigations on the spawning grounds have shown that the variable success of different broods does not depend as much on the number of eggs spawned as on the survival of the newly hatched young mackerel fry. Oceanographic work is now being carried on to determine what conditions in the sea cause high survival rate in some years and catastrophic mortality in others.

The bird life of Mt. Duida, Venezuela: FRANK M. CHAPMAN. Although it was discovered about 1750, Mt. Duida, near the headwaters of the Orinoco, Venezuela, was first ascended by an American Museum of Natural History expedition in 1928. It was found to be part of a hitherto unknown tableland of approximately 250 square miles in extent with an elevation of from 4,200 to 7,800 feet. The fauna and flora of this area was of the subtropical zone and composed in large part of new species, but with a marked affinity to the life heretofore known only from Mt. Roraima, 400 miles to the east. About one fourth the bird-life of this subtropical tableland has been derived from tropical ancestors still existing in the tropical zone at its base. These birds are usually larger and darker than those from which they have been derived and thus represent the influence on the organism of higher altitude and greater humidity acting under isolation. About one half the avifauna shows a more or less close resemblance to species occupying the corresponding life zone in the Andes, often at a distance of a thousand miles or more. The existence of these representative forms in such widely separated regions is explained by the theory that their common ancestors, or connecting forms, have disappeared from the intervening area. The remaining fourth of the avifauna is too distinct to afford evidence of its immediate ancestry and, it is possible, may be representative of the bird life of the great tableland of which Mt. Duida and Mt. Roraima are a surviving part.

The aerological results of the Greenland Expeditions of the University of Michigan: WM. H. HOBBS (introduced by John C. Merriam). The three Greenland Expeditions of the University of Michigan had for their primary object the study of the surface and upper-air currents near the border of the great ice-cap of Greenland—the glacial anticyclone. In 1926 a temporary base was established on the Maligiakfjord in latitude 66° 55′ north, 50 kilometers in from the sea and 100 kilometers distant from the inland-ice margin, where some 84 pilot balloon ascents were carried out. In 1927 a permanent station was established in an excellent position on Mt. Evans at the head of the Söndre Strömfjord. This station is in the same latitude as that of 1926, but is 120 kilometers from the coast and only about 30 kilometers distant from the edge of the inland ice. It was maintained in continuous operation for two full years. Pilot balloon ascents at Mt. Evans were made on all clear days, numbering 776, and were carried to an average altitude of 7,000 meters. Two exceptional runs on June 6 and August 6, 1928, were carried to altitudes of 29,000 and 27,000 meters respectively. This paper includes a summary discussion of results and a comparison of these with 35 balloon runs carried out by the Norwegian Meteorological Institute at Mygbukta in latitude 23° on the Greenland east coast.

A microscope-centrifuge (illustrated): E. NEWTON HARVEY and ALFRED L. LOOMIS (introduced by E. G. Conklin).

Certain scientific aspects of air transportation (illustrated): JOSEPH S. AMES.

Biographical memoir of John Trowbridge (to be read by title): EDWIN H. HALL.

Biographical memoir of Charles F. Chandler (to be read by title): MARSTON T. BOGERT.

Drop of potential and state of ionization near the cathode of a mercury arc: K. T. COMPTON and E. S. LAMAR. The exploring electrode method of Langmuir and Mott-Smith has been employed to investigate conditions in the region of the cathode of a mercury arc, supplementing a preliminary investigation by Killian (*Phys. Rev.* 31: 632, 1928). The cathode was designed so as to minimize the wandering of the cathode spot over the surface of the mercury. A movable exploring electrode was used whose thermal dissipating power was sufficiently great to prevent its melting while in the cathode region. The observations yielded values for space potential, the mean kinetic energy of the electrons and the electron concentration over distances ranging from .411 to 1.943 cm from the cathode. Space potential was found to be constant over this range and of value about 10 volts with respect to the cathode. If we allow a few tenths of a volt for contact differences in potential, then the indications are that the value of the cathode fall is quite near to the ionization potential of mercury. The assumption that in field free space the current is carried by diffusion of electrons permits estimates of the values of the electron mean free paths which are in fair agreement with those which would be expected from other experiments. The average energy of the electrons, in equivalent volts, is constant at 0.98 volt for distances between 0.8 and 2.0 cm from the cathode. At closer distances the average energy rises rapidly, being, for example, 1.3 volts at 0.51 cm and 1.7 volts at 0.38 cm. The electron and ion concentrations increase as the cathode is approached. Typical values are 0.34 $(10)^{12}$ electrons (or ions) per cm^3 at 1.94 cm, 1.5 $(10)^{12}$ at 0.79 cm and 2.9 $(10)^{12}$ at 0.44 cm. The reflection coefficient of the electrons at the surface of the tungsten collector is about 0.4. The above values are for 4.8 ampere arcs. If the current is increased to 11.0 amperes, the cathode drop is unchanged, the average energy of the electrons is slightly decreased and their concentration is increased at least ten fold. With the higher currents there is also a region of slightly reversed field just beyond the cathode fall space.

The "reaction-isochore" equation for ionization within metals: EDWIN H. HALL. In the relation

$$U = KT^2 \frac{d\ln K}{dT} \qquad (1)$$

called by Nernst the "reaction-isochore" equation, U is

the heat given out when a reversible isothermal reaction is carried on with the system maintained at constant volume, so that no external work is done. K is the "equilibrium constant" of the reaction, a quantity which does not change while the reaction is carried on isothermally. This equation has a firm thermodynamic foundation for reactions that can be reasonably conceived of as performed under certain conditions, first described by van't Hoff. The author has long held that these conditions can not be conceived of as holding for the process of ionization within a solid metal, and he has therefore ignored equation (1) in his speculations concerning ionization, making certain hypotheses and reaching corresponding numerical conclusions without regard to any limitation imposed by this equation. He now finds that, for every one of the many metals studied, his numerical conclusions are consistent with an equation,

$$U = f \cdot KT^2 \frac{d\ln K}{dT} \qquad (2)$$

identical with equation (1) except for the presence of a numerical factor, f, in the second number. The value of f ranges from about 1.33 in nickel to about 3.13 in manganin, but for any one metal, though perhaps not entirely independent of temperature, it changes little if at all between 0° C. and 100° C.

Accommodation coefficients and heats of neutralization of gas ions at electrodes: K. T. Compton and C. C. Van Voorhis. When positive ions of a gas strike an electrode and become neutralized there are energy interchanges which result in heating of the electrode. Knowledge of this heating is important both in the interpretation of the physical phenomena which are involved and also in the practical design of gas discharge devices. With the aid of a thermocouple, and using this thermocouple as an exploring electrode in the ionized atmospheres of arcs at low gas pressures, we have studied the following factors which contribute to this heating: (1) the fraction of the incident kinetic energy of the ion which is delivered to the electrode (accommodation coefficient); (2) the fraction of the energy given to the ion by an applied electric field which is retained by the ion in spite of collision with gas molecules while approaching the electrode; (3) the portion of the apparent positive ion current to the electrode which is in reality due to electrons liberated from it under the influence of ultra-violet light, metastable atoms and positive ion impact; (4) the true "heat of neutralization" of the ion at the surface. The new and most important result of this work is the discovery that a considerable fraction of the kinetic energy of an impacting ion is retained after impact by the neutralized atom. The remaining fraction, which is delivered to the electrode as heat, is analogous to the "accommodation coefficient" which is recognized in the impact of ordinary gas molecules against a heated surface. In general these accommodation coefficients appear to approach unity for ions (or molecules) of high molecular weight. Our values are about 0.45, 0.7, 0.8 for ions of He, Ne and A, respectively. The existence of an accommodation coefficient less than unity, as thus proved by energy measurements, implies also that mechanical momentum is imparted by ions to electrodes in much larger extent than has hitherto been suspected. There are several observations on electrode arcs, which have been rather obscure, which seem thus to find a ready explanation. Of the four factors mentioned above as the objectives of our work, the first three are relatively so large in their effect that we have as yet been unable to arrive at definite conclusions regarding the fourth—the true heat of neutralization of an ion—whose determination would settle some interesting speculations regarding the mechanism of electric arcs.

The deformation of ions and the various types of chemical linkage: K. Fajans (by invitation). One distinguishes usually two main types of chemical linkage, the polar or ionic and the non-polar or covalent linkage. The polar linkage is typified by the inorganic salts, such as sodium chloride; the non-polar linkage by the bond between the two atoms in the hydrogen molecule or by the linkage between the carbon atoms in the diamond and in organic compounds. According to the modern conception of atomic structure the ionic linkage in sodium chloride is produced by the transfer of one electron from the sodium atom to the chlorine atom. The electrostatic attraction between the resulting positively charged sodium ion and the negatively charged chlorine ion holds them together to form a molecule or a crystal lattice. In the non-polar linkage the two atoms are assumed to be joined together by a pair of electrons shared by both atoms, and revolving round their nuclei. Between these two main types of chemical linkage there exists a whole series of transition types. Beginning with the ideal ionic linkage these transition types can be understood as the result of the polarization (deformation) to various degrees, of the electron shell of the anion by the electric field of the cation. The degree of this deformation and consequently the deviation from the ionic linkage and the approach to the non-polar linkage is greater when the radius of the cation is smaller, its charge higher and when the deformability of the anion is greater. This approach to the non-polar linkage is also more pronounced for cations which do not show the rare-gas structure than for cations with this structure.

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